DECEMBER 1959

Journal

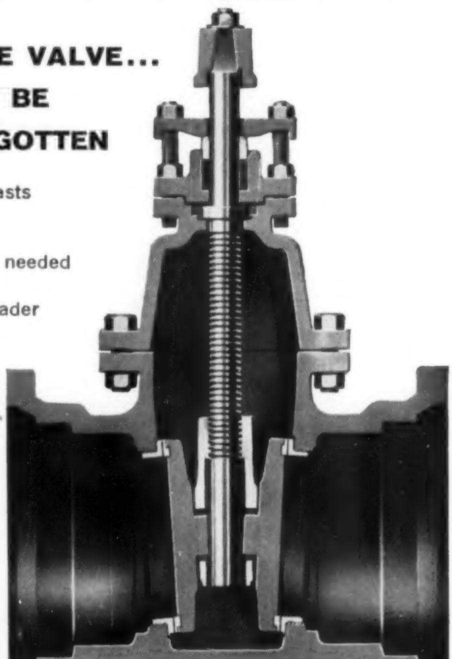
VOL. 51 • NO. 12

AMERICAN WATER WORKS ASSOCIATION

In this issue:

Aquatic attic stores 28,000-gal supply for Suffolk, England (see p. 38 P&R)

1960 AWWA CONFERENCE
Bal Harbour, May 15–20



Journal

AMERICAN WATER WORKS ASSOCIATION

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Plan now for

AWWA ANNUAL CONFERENCE

Bal Harbour, Fla. May 15–20, 1960

Coming Meetings

AWWA SECTIONS

Winter-Spring 1960

Jan. 26—New York Section, Midwinter Luncheon Meeting, at Park Sheraton Hotel, New York. Secretary, Kimball Blanchard, Neptune Meter Co., 2222 Jackson Ave., Long Island City 1.

Feb. 3–5—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, C. H. Canham, State Board of Health, 1330 W. Michigan St., Indianapolis.

Mar. 16–18—Illinois Section, at Pick-Congress Hotel, Chicago. Secretary, D. W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago 1.

Mar. 17—New England Section, at Statler Hotel, Boston, Mass. Secretary, R. M. Soule, Assoc. San. Engr., State Dept. of Public Health, 511 State House, Boston, Mass.

Mar. 20–23—Southeastern Section, at De Soto Hotel, Savannah, Ga. Secretary, N. M. de Jarnette, Engr., Water Quality Div., State Dept. of Public Health, 309 State Office Bldg., Atlanta, Ga.

Mar. 23–24—West Virginia Section, at Hotel Pritchard (tentative), Huntington. Secretary, H. W. Hetzer, Engr., Union Carbide Chemical Co., Box 8361, South Charleston.

Apr. 5–7—New York Section, at New York Sheraton-Binghamton, Binghamton. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 2222 Jackson Ave., Long Island City.

Apr. 20–22—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, J. J. Rossbach Jr., Civ. Engr., Metropolitan Utilities Dist., 3906 N. 48th St., Omaha.

Apr. 20–22—Kansas Section, at Broadview Hotel, Emporia. Secretary, H. W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina.

Apr. 22—California Section, at Mark Thomas Inn, Monterey. Secretary, R. E. Dodson Jr., Supt. of Water, Dept. of Utilities, Balboa Park, San Diego.

Apr. 24–26—Canadian Section, at Statler Hotel, Buffalo, N.Y. Secretary, A. E. Berry, 72 Grenville St., Toronto, Ont.

Apr. 28–30—Arizona Section, at Pioneer Hotel, Tucson. Secretary, A. D. Cox Jr., Secy. & Comptroller, Arizona Water Co., Box 5347, Phoenix.

(Continued on page 10)

Coming Meetings

(Continued from page 8)

Apr. 28–30—Montana Section, at Northern Hotel, Billings. Secretary, A. W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

May 4–6—Pacific Northwest Section, at Benson Hotel, Portland, Ore. Secretary, F. D. Jones, W. 2108 Maxwell Ave., Spokane 11, Wash.

Jun. 14–17—Pennsylvania Section, at Hilton Hotel, Pittsburgh. Secretary, L. S. Morgan, 413 First National Bank Bldg., Greensburg.

Fall 1960

Sep. 12–14—Kentucky-Tennessee Section, at Andrew Johnson Hotel, Knoxville, Tenn. Secretary, Harold F. Mount, Gen. Mgr., Preston Street Road Water Dist. No. 1, 5400 Preston Hwy., Louisville, Ky.

Sep. 14–16—Virginia Section, at Cavalier Hotel, Virginia Beach. Secretary, Edward H. Ruehl, R. Stuart Royer & Assoc., 15 W. Cary St., Richmond.

Sep. 21–23—Michigan Section, at Park Place Hotel, Traverse City. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing.

Sep. 21–23—North Central Section, at Sheraton-Contaract Hotel, Sioux Falls, S.D. Secretary, Carl A. Flack, Registrar, Water Dept., 216 City Hall, St. Paul, Minn.

Sep. 25–27—Missouri Section, at Governor Hotel, Jefferson City. Secretary, Warren A. Kramer, Chief, Water Supply, Div. of Health, State Office Bldg., Jefferson City.

Sep. 28–30—Wisconsin Section, at Loraine Hotel, Madison. Secretary, Harry Breimeister, Bureau of Engineers, 607 Municipal Bldg., Milwaukee.

Sep. 28–30—New York Section, at Whiteface Inn, Whiteface. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 2222 Jackson Ave., Long Island City 1.

Oct. 9–12—Alabama-Mississippi Section, at Tutwiler Hotel, Birmingham, Ala. Secretary, Ernest Bryan, McWane Cast Iron Pipe Co., Box 2601, Birmingham, Ala.

Oct. 16–19—Southwest Section, at Galvez Hotel, Galveston, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 19–21—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19–21—Chesapeake Section, at Sheraton Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Oct. 23–26—Rocky Mountain Section, at Broadmoor Hotel, Colorado Springs, Colo. Secretary, Harrison F. Kepner, Vice-Pres., Dana Kepner Co., 550 Alcott, Denver, Colo.

Oct. 24–27—California Section, at Lafayette Hotel, Long Beach. Secretary, F. F. Watters, Hydr. Engr., State Public Utilities Com., Civic Center, San Francisco 2.

Oct. 26–28—Ohio Section, at Deshler-Hilton Hotel, Columbus. Secretary, J. Howard Bass, Henry P. Thompson Co., 1720 Section Rd., Cincinnati.

Nov. 9–11—North Carolina Section, at Robert E. Lee Hotel, Winston-Salem. Secretary, T. Z. Osborne, Asst. Director of Public Works, Greensboro.

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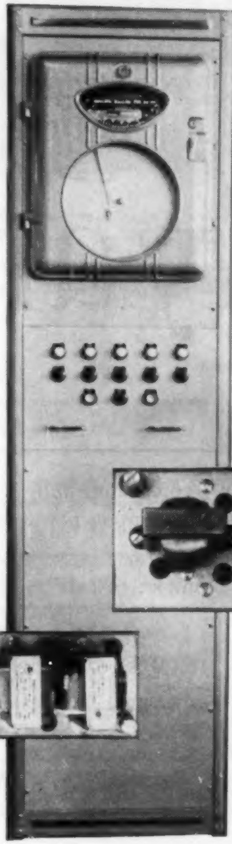

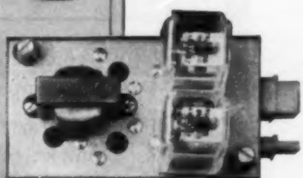

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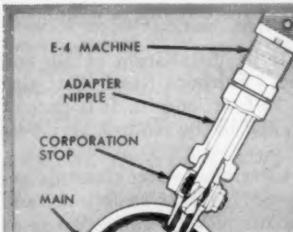

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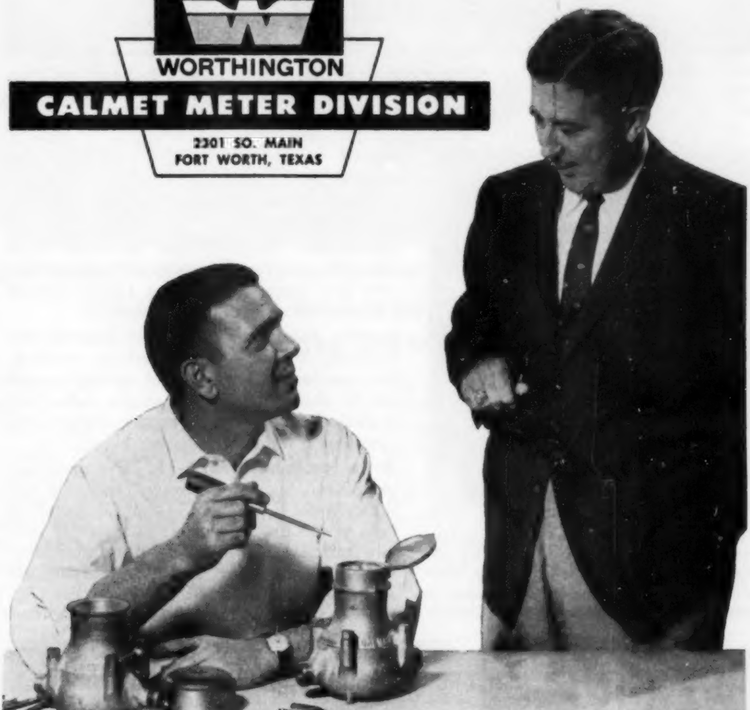

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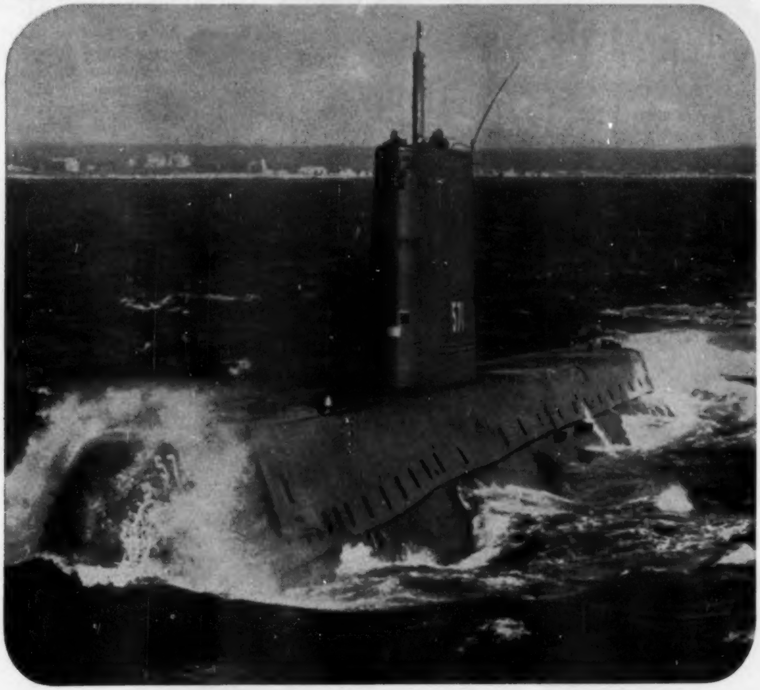

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VOL. 51 • DECEMBER 1959 • NO. 12

Survey on Compensation of Water Utility Managers, 1957

Committee Report

A report of Committee 4230 M—Compensation of Water Utility Personnel, presented on Jul. 16, 1959, at the Annual Conference, San Francisco, Calif., by Garvin H. Dyer (Chairman), Vice-Pres. & Chief Engr., Independence Div., Missouri Water Co., Independence, Mo. Other members of the committee are W. R. Gelston, H. J. Graeser, J. C. Luthin, and R. A. Thompson Jr.

ON a production basis, the water supply industry is by far the largest in the United States. It produces as great a tonnage of product in a single day as the steel industry produces in an entire year; in 16 hr it produces practically the same tonnage as the oil industry does in a year; it must operate but 7 days to match the yearly tonnage of bituminous coal produced; in only 9 days of operation it equals the combined yearly output of all three of the industries mentioned.

Water is also transported on a tremendous scale. Water utilities transport almost 80,000,000 tons of safe drinking water each and every day. In a little less than a month a greater tonnage of water is transported than all of the tonnage transported by railroads in the United States in a year.

But the production of water is important not only because it is the largest industry in production and transportation; it is the most essential industry from the standpoint of need. Life is impossible without an ample supply of safe, wholesome water. Modern civilization has made it necessary to collect, treat, safeguard, and transport water in the most efficient manner possible, and the water supply industry has, of necessity, become highly specialized. It has also had to become very efficient, or the cost of water would be much higher than it is.

In order to maintain and advance the water supply industry, it is essential that the most competent and best qualified people be attracted to it. There is intense competition in all industry today for capable personnel. The only way that any industry can

attract and retain this essential personnel is to offer salaries comparable to those paid in other industries to people with comparable qualifications in positions of comparable responsibility. The shortsighted policy of too many water utilities of paying the lowest salary possible is false economy. Although it may result in slightly lower water rates today, it is certain to result in much higher water rates in the future. Incompetent employees are costly no matter how little they are paid.

Preliminary Study and Survey

The Committee on Compensation of Water Utility Personnel was reactivated in 1957. The committee realized that before any sound recommendations could be made it would be necessary to obtain basic data on salaries presently being paid in the industry. Because there is a large variation in the size of water utilities and, consequently, in the responsibilities of managerial personnel, it is necessary to relate salaries to responsibilities. Also, in order to determine whether present salaries are fair and reasonable, it is necessary to compare the salaries paid to water utility personnel with the salaries paid to corresponding personnel in other industries, especially in the electric and gas utilities.

A preliminary study indicated that employees of water utilities were, for the most part, not being paid a wage comparable to that paid in other industries for positions of like responsibility. There was also strong indication that many utility managers are underpaid, which automatically places a wage ceiling on all of the employees under their jurisdiction. Therefore, the committee felt that its first concern should be with the salaries paid to the top administrators of water utilities.

The committee believes that, once the wage ceiling (the manager's salary) has been properly established, the wages of the other personnel tend to seek proper levels corresponding to responsibilities. It should be the duty of the water utility manager to establish proper salary levels for all employees under his jurisdiction.

In order to obtain the information necessary for a study of managerial salaries, the committee found it necessary to conduct a survey. The objectives of that survey were:

TABLE 1

Method of Random Selection, Cities of 25,000 Population or Less

Population Range *1,000's*	No. Selected per State	How Selected in Each State
10–25	6	Alphabetically, starting with "A"
5–10	5	Alphabetically, starting with "F"
2.5–5	4	Alphabetically, starting with "K"
1–2.5	4	Alphabetically, starting with "P"
<1	4	Alphabetically, starting with "U"

1. To ascertain what salaries water utility managers are being paid and to relate those salaries to their responsibilities as determined by capitalization, population served, miles of mains under their jurisdiction, gross annual revenues, amount of water delivered annually, and the number of employees supervised

2. To compare the salaries of water utility managers with those of men in comparable positions in other industries, especially in other utility fields

3. To develop recommended salary ranges for the year 1959 for managers of utilities serving various population sizes and in accordance with responsibilities

4. To recommend experience and educational qualifications for water utility managers

5. To establish a yardstick whereby both managers and their employers would be able to ascertain proper salary levels according to responsibilities.

Nature of Survey

An extensive questionnaire was mailed to 1,585 managers of water utilities in the United States and to 413 in Canada. The final cutoff date for the survey was Feb. 1, 1959. The names of the managers in the United States were obtained primarily through the state sanitary engineers; in Canada names were obtained from the 1958 annual directory of *Municipal Utilities* magazine.

The committtee chose to include all cities in the United States and Canada with a population (1950) of 25,000 or more. To survey all of the smaller cities would have required a great deal of work and expense and would not have added materially to the results and conclusions obtained. The cities in the United States with a population less than 25,000 were therefore selected at random, as shown in Table 1.

Table 2 is a tabulation of the number of cities in each population range, and the number of questionnaires distributed in each range. A total of 828 usable questionnaires was returned from managers in the United States. This represents a return of more than 52 per cent. Questionnaires were returned by 48 managers of utilities that serve populations of more than 250,000 people and 80 from those that serve populations of 100,000–250,000; the 1950 United States census listed only 41 cities of 250,000 population and only 65 cities of 100,000–250,000. This might, at first glance, appear to be a discrepancy, but two factors are involved: [1] the increase in population of many cities since the 1950 census and [2] the number of water utilities that serve many customers outside the corporate limits of the city or serve more than one municipality. The latter situation is especially prevalent in the larger communities. The respondents were requested to report the estimated population served and not the population of any one city.

TABLE 2

Questionnaire Distribution by Population Groups

Population Range *1,000's*	No. of Towns in Range	No. of Towns Selected
>1,000	5	5
500–1,000	13	13
250–500	23	23
100–250	65	65
50–100	126	126
25–50	249	249
10–25	752	288
5–10	1,093	240
2.5–5	1,557	192
1–2.5	3,408	192
<1	9,827	192

There are 771 water utilities in Canada. In cities of less than 25,000 population, questionnaires were sent to every other one listed in the 1958 annual directory of *Municipal Utilities* magazine. Questionnaires were mailed to 74 managers of water utilities in cities of 25,000 population or more, and 339 were sent to those in cities of less than 25,000 population. Of the former,

41 were returned (55 per cent), and of the latter, 81 (24 per cent) were returned. The total number of questionnaires returned from Canada was 122, or approximately 30 per cent.

In order to facilitate the tabulation of the information, most questions in

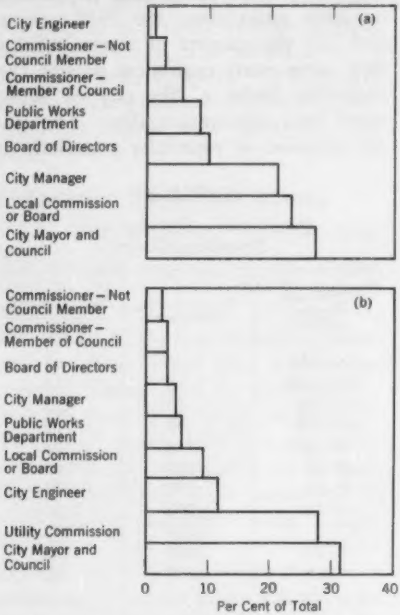

Fig. 1. Persons or Bodies to Whom Water Utility Managers Reported, 1957

Part (a) is a breakdown of United States respondents; Part (b) is the same for Canadian respondents. Those reporting to a board of directors, of course, are managers of privately owned utilities; all others are managers of publicly owned utilities.

the questionnaire were broken down into nine ranges. Known relationships were taken into consideration in setting up the questionnaire so that a particular range under one of the questions was of the same general size and responsibility as the corresponding range in all questions. The selected income ranges are given below:

Range No.	Annual Salary *$1,000*
1	1–3
2	4–6
3	7–9
4	10–12
5	13–15
6	16–18
7	19–21
8	22–24
9	25–27

In computing medians and upper and lower quartiles, the breakpoint was selected at the midpoint between the highest figure in one range and the lowest figure in the succeeding range—for example, Range 2 covers salaries of $3,501–$6,500.

Definitions

In the interest of uniformity and for ease of understanding, the following definitions were provided:

1. *Manager.* The chief executive whose direct responsibility is the management of the water utility even though his title may actually be superintendent, general manager, president, director, chief operator, commissioner, or other
2. *Salary.* The 1957 annual salary, or portion thereof, received by the manager for his work as manager of the water utility only
3. *Median.* The point in any array of data above and below which half of the series is located (The value of the median is that it can immediately be computed even if the series contains open-end class intervals, such as "less than $1,000" and "$27,000 or more" as used in this survey.)
4. *Upper quartile.* The point in any array of data above which one-fourth

of the series is located and below which three-fourths of the series is located

5. *Lower quartile.* The point in any array of data above which three-fourths of the series is located and below which one-fourth of the series is located

6. *Highest.* The highest salary indicated in a particular series of data

7. *Lowest.* The lowest salary indicated in a particular series of data (When the number reporting was one or two, the middle figure of the lowest salary range marked was shown; when the number reporting was three or more, the lowest figure of the lowest salary range marked was shown.).

Fig. 2. Geographic Distribution of Respondents and Annual Salaries by Region, 1957

Canadian and United States regions are numbered independently. Shown are the number of respondents in each region, the percentage of total respondents in each country, and the average annual salary paid to managers in each region.

(When the number reporting was one or two the middle figure of the highest salary range marked was shown, and when the number reporting was three or more, the top figure of the highest salary range marked was shown.)

Administrative Types

In the United States, 10 per cent of the respondents reported that they were employed by privately owned utilities, and 90 per cent were employed by publicly owned utilities; in

Canada, 3.3 per cent were employed by privately owned utilities and 96.7 per cent were employed by publicly owned utilities. A breakdown according to administrative types in both the United States and Canada is given in Fig. 1. More publicly owned water utilities in both the United States and Canada are directly under a mayor and council than any other type of administrative system—27.2 per cent in the United States and 31.4 per cent in Canada. The next largest group in Canada (28 per cent) reported that they were under the Canadian public utilities commissions. In the United States the second highest group (23.4 per cent) was under a local commission or board, and the third largest group (21.1 per cent) was under a city manager. It should be taken into consideration that only a small percentage of cities with a population of less than 25,000 was surveyed. If all cities had been surveyed, the percentages would probably have been different.

Geographic Distribution

More than half of the respondents in the United States reported that they worked in the Mid-Atlantic, Midwestern, and New England states. The percentage of respondents followed rather closely the percentage of total population in the various areas (Fig. 2).

The returns indicated that the percentage of privately owned water utilities is greater in the northeastern states than in the rest of the country. Again it must be remembered that only a few of the plants in cities of less than 25,000 population were surveyed.

Education

As an adequate formal education is a prerequisite for most jobs, it is of interest to note that of the 810 United States managers who responded 40.6 per cent had a college education or better and 83.7 per cent had at least a high school diploma. In other words, only 16.3 per cent of them had less than a high school education.

Because there were relatively few respondents from the smaller water utilities, which actually constitute a very large majority of the national total and are known to employ managers with less formal education than the larger systems, it is felt that the results of the survey give too optimistic a picture of educational qualifications. A summary of the results for both the United States and Canada is given in Table 3.

TABLE 3

Educational Attainments of Water Utility Managers

Educational Attainment of Manager	United States Utilities			Publicly and Privately Owned Canadian Utilities *per cent*
	Privately Owned *per cent*	Publicly Owned *per cent*	Privately and Publicly Owned *per cent*	
Less than high school	11.7	16.8	16.3	18.5
High school or more	88.3	83.2	83.7	81.5
College or more	45.5	40.0	40.6	50.0
Postgraduate	11.7	10.0	10.1	8.8

TABLE 4

College Majors of Water Utility Managers

Major	United States Managers		Canadian Managers	
	No.	Percentage	No.	Percentage
Civil or sanitary engineering	175	49.2	36	63.2
Other engineering	71	20.0	11	19.3
Accounting	8	2.3	1	1.7
Biology	1	0.3	0	0
Business administration	28	7.9	1	1.7
Chemistry	26	7.3	2	3.5
Geology	0	0	0	0
Government or public administration	14	4.0	3	5.3
Other	32	9.0	3	5.3
Totals	355	100.0	57	100.0

Analysis of the data set forth in Table 3 reveals a striking similarity between the educational qualifications of managers in the United States and Canada. The only significant differences noted are those between the educational qualifications of the managers employed by privately and publicly owned utilities in the United States. In this comparison managers of privately owned utilities show slightly higher educational atttainments than do their counterparts in publicly owned water utilities.

In Canada, only four questionnaires were returned by managers of privately owned utilities, and no valid comparison was, therefore, possible.

Major College Subject

Analysis of the major undergraduate subjects taken by managers in both the United States and Canada shows a predominance of engineering courses. In Canada, 82.4 per cent of the 57 college graduates majored in engineering; in the United States, 69.2 per cent of 329 college graduates were engineers.

The popularity of other professional courses or curricula was minor by comparison, as shown in Table 4.

In-Service Training

It appears that in-service training courses are not nearly so popular with water utility managers in the United States as has been supposed. For example, of 806 respondents, 474, or 58.8 per cent, had not attended a training course. The remaining 332 managers attended a total of 1,209 courses, an average of 3.6 courses per manager. In Canada such courses are even less popular; of 117 managers, 93, or 79.4 per cent, had not attended a course. The 24 managers who did attend in-service courses averaged about two each. A complete analysis of the statistics is given in Table 5. There appears to be no significant difference between privately and publicly owned

TABLE 5

In-Service Training of Water Utility Managers

No. of Courses Taken	United States Managers		Canadian Managers	
	No.	Percentage	No.	Percentage
0	474	58.8	93	79.4
1	63	7.8	12	10.3
2	77	9.5	6	5.1
3	55	6.8	5	4.3
4	45	5.6	0	0
5	20	2.5	0	0
6	11	1.4	0	0
7	7	0.9	0	0
8 or more	54	6.7	1	0.9
Totals	806	100.0	117	100.0

water utilities in the population of in-service training.

Correspondence Courses

Relatively few correspondence courses are taken by water utility managers. Only 175 of 805 respondents (21.7 per cent) took such courses, and the average number of courses taken per manager was two.

In Canada only 22 of the 117 respondents took correspondence courses, and the average number of courses taken was 1½.

TABLE 6

Compensation of Registered-Engineer and Nonengineer Managers

Salary *$1,000's*	Registered Engineers		Nonengineers	
	No.	Percentage	No.	Percentage
1–3	33	13.1	198	35.5
4–6	63	25.1	214	38.3
7–9	81	32.2	108	19.3
10–12	40	16.0	26	4.6
13–15	24	9.6	7	1.2
16–18	2	0.8	4	0.7
19–21	5	2.0	0	0
22–24	1	0.4	0	0
25 or more	2	0.8	2	0.4
Totals	251	100.0	559	100.0

Engineering Graduates

As the large majority of the managers answering the questionnaire had engineering training, it was interesting to determine whether the water industry was getting its share of new engineering graduates. Utilities were asked how many engineering graduates they employed directly from college for the years 1955–57. The results of the inquiry were anything but encouraging: 93.2 per cent of the United States utilities and 87.2 per cent of the Canadian utilities employed no new engineering graduates during the 3-year period. United States utilities employed 296 graduates during the 3-year period, for an average of 99 per year. As 824 utilities reported in the survey, the 99 graduates represent one new graduate per year for 8.3 utilities reporting. As the survey included all of the large towns and relatively few of the small towns, this conclusion is unduly optimistic.

In Canada, 74 new engineering graduates were employed during the 3-year period, or 25 per year. With 117 utilities reporting, this number represents one graduate per 4.7 utilities, or almost twice the rate in the United States.

Engineering Registration

Engineering registration among water utility managers in Canada is higher by 17.1 per cent than in the United States. In Canada, 47.9 per cent of the 117 managers answering the inquiry were registered professional engineers, whereas only 30.8 per cent of the 814 United States managers were registered engineers.

Analysis of the compensation of registered-engineer and nonengineer managers in the United States (Table 6) indicates that registered-engineer managers receive higher salaries. This is undoubtedly because engineer-managers are usually employed in larger communities.

Responsibilities

In the survey an attempt was made to learn what duties or responsibilities water utility managers had in addition to the basic ones of supervising distribution, treatment, production, maintenance and repair. The committee wished to learn what administrative

responsibilities were his, if any. The survey results are shown in Table 7.

It is evident from Table 7 that the managers of privately owned utilities have more responsibilities than managers of publicly owned utilities. In six of the nine duties listed in the table, the managers of United States utilities also appear to be busier than their Canadian counterparts.

Experience

If the statistics developed by the survey can be taken as an accurate indication, the tenure of service of water utility managers in the United States is substantially longer than in Canada. For example, 49.5 per cent of the managers in Canada have held their jobs for only 1–5 years, whereas just 32.8 per cent of the United States managers are in this category. Table 8 presents the comparison.

An explanation of the variations in tenure seems too difficult to be worthwhile. It is sufficient to point out that in the United States 28.9 per cent and in Canada 19.7 per cent of the managers have served for more than 15 years. Similarly, for a tenure of more than 10 years the percentages are 42.6 and 25.7 for the United States and Canada respectively.

A comparison of tenure of managers of utilities under public and private ownership in the United States shows that job security is a bit better under private ownership. For example, 50.0 per cent of the managers of privately owned utilities have had more than 10 years of service compared with 41.7 per cent for managers of publicly owned systems.

TABLE 7

Administrative Responsibilities of Water Utility Managers by Utility Ownership

Duty of Manager	United States Utilities						Canadian Utilities	
	Publicly Owned		Privately Owned		Privately and Publicly Owned		Privately and Publicly Owned	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Billing and customer accounting	374	52.5	53	68.8	427	54.1	28	26.4
Budget preparation	483	67.8	57	74.0	540	68.5	82	77.3
General accounting	291	40.8	33	42.9	324	41.1	30	28.3
Purchasing	531	74.6	61	79.2	592	75.0	81	76.4
Personnel (hiring and firing)	560	78.6	67	87.0	627	79.5	81	76.4
Planning	565	79.2	67	87.0	632	80.2	71	67.0
Engineering	447	62.8	51	66.2	498	63.2	76	71.7
Construction	600	84.2	66	85.8	666	84.5	88	83.0
Public relations	525	73.6	68	88.3	593	75.3	61	57.6

Civil Service

Civil service is applicable to publicly owned utilities only. In both the United States and Canada the percentages of managers under civil service are surprisingly low. For Canada, only 15.1 per cent have civil service status. In the United States, only

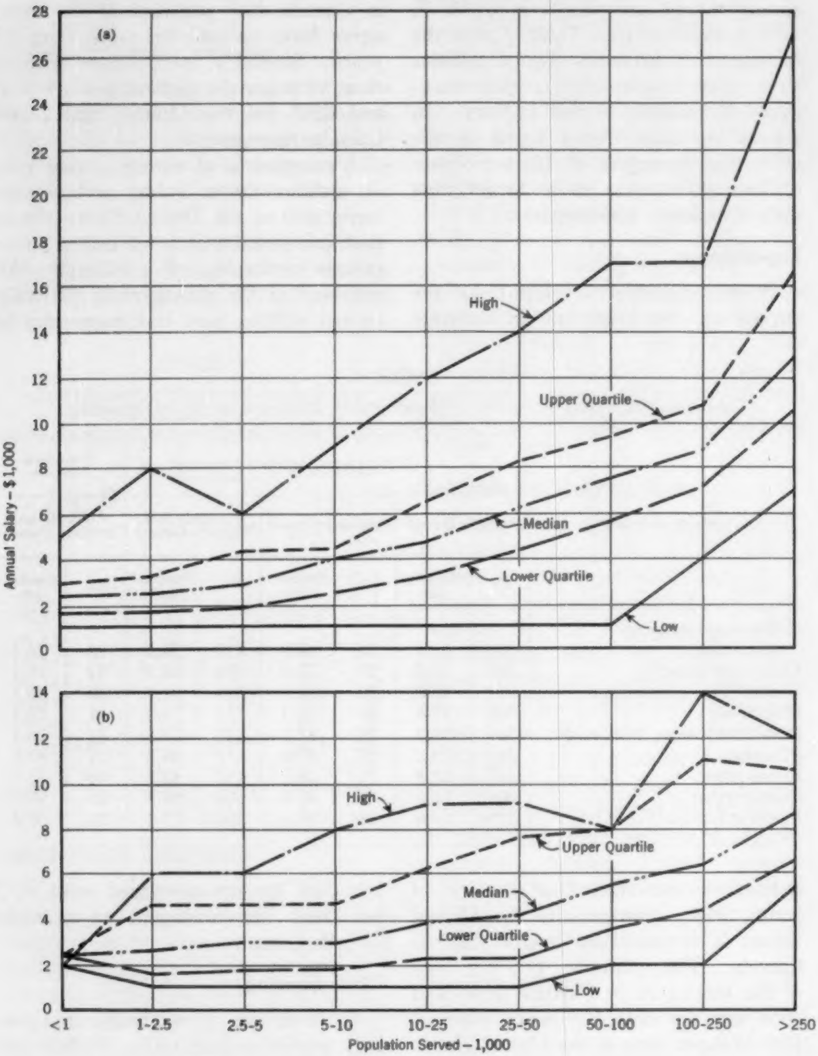

Fig. 3. Managers' Salaries by Population Served by Utility, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

19.5 per cent have civil service coverage.

Earnings and Responsibilities

Figure 3 gives a breakdown of the salaries of the respondents as related to the population served by their utility. As was expected, the larger salaries generally were earned by those who managed utilities in larger cities. It will be noted that there is a wide range between the lowest salary and the highest salary, but that the median and the upper and lower quartiles are relatively close together in the United States. In Canada the range between highest and lowest salaries is not as great as in the United States, but the range between the upper and lower quartiles is greater.

For the purpose of this survey, the manager's area of responsibility was classified according to the population served, quantity of water delivered, miles of distribution mains, gross annual operating revenue, historical cost of utility, and number of employees under his jurisdiction. Each of the areas of responsibility was broken down into nine ranges. Known data made it possible to set up corresponding ranges in each of the areas of responsibility so that, in general, the ranges for each classification referred to utilities requiring similar responsibilities of their managers.

The very close relationship between the ranges of the various areas of responsibilities, as related to salaries, is indicated in Fig. 4–8. Variations are to be expected, but the trend is uniform.

As there is such a close relationship between the ranges in the nine classifications of areas of responsibility it is possible to set up a composite grouping of the responsibilities into classifications and relate them to a composite of the manager's annual salary, as in Table 9. A graphical presentation of this information is contained in Fig. 9.

The population served by the utility was related to the number of customers, quantity of water delivered, miles of distribution mains, gross annual operating revenue, historical cost of utility, and number of employees under the manager's jurisdiction. A close relationship between the ranges in the various responsibility classifications is apparent. This close relationship made it possible to set up a table of managerial responsibilities by general classification (Table 10).

TABLE 8

Job Tenure of Water Utility Managers

Tenure *Years*	United States Managers		Canadian Managers	
	No.	Percentage	No.	Percentage
1–5	269	32.8	58	49.5
6–10	201	24.6	29	24.8
11–15	112	13.7	7	6.0
16–20	93	11.4	5	4.3
21–25	52	6.3	7	6.0
>25	92	11.2	11	9.4
Totals	819	100.0	117	100.0

Earnings and Administrative Setup

Of the four respondents in the United States receiving an annual salary of more than $24,500, two were employed by privately owned utilities and two by publicly owned utilities. Both of the latter reported directly to a local commission or board. Of the ten respondents in the United States receiving an annual salary of more than $18,500, four were employed by

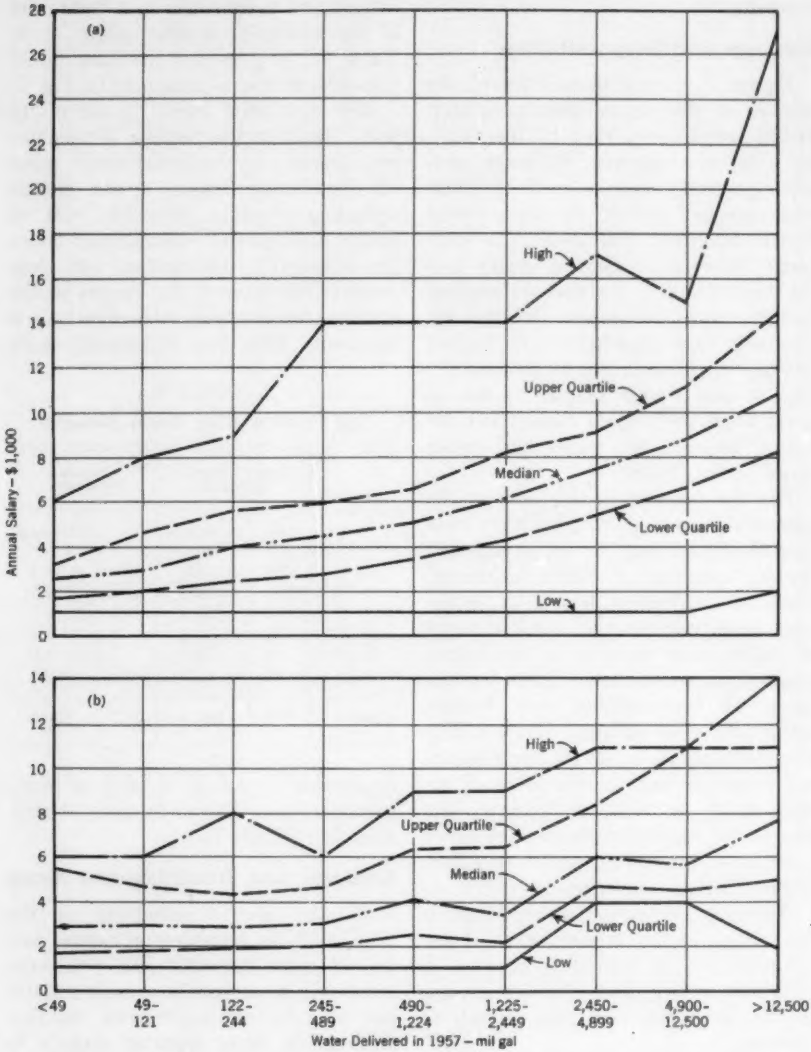

Fig. 4. Managers' Salaries by the Amount of Water Delivered to System, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

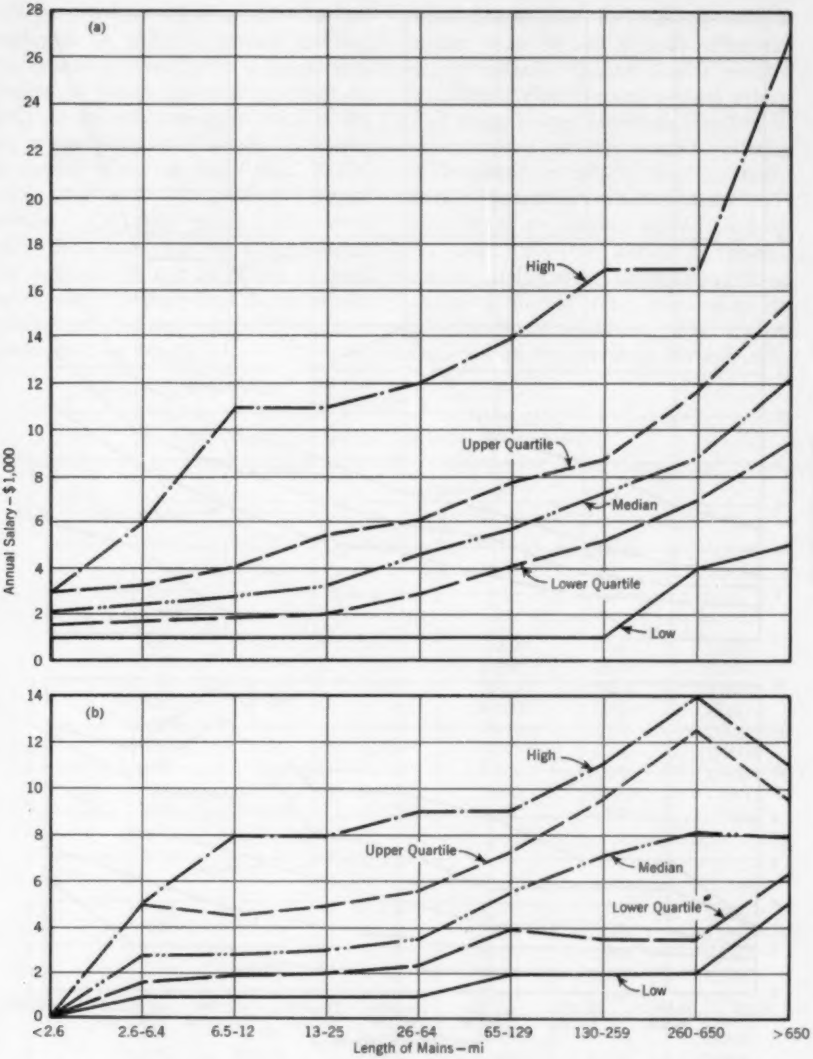

Fig. 5. Managers' Salaries by Length of Distribution Mains in System, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

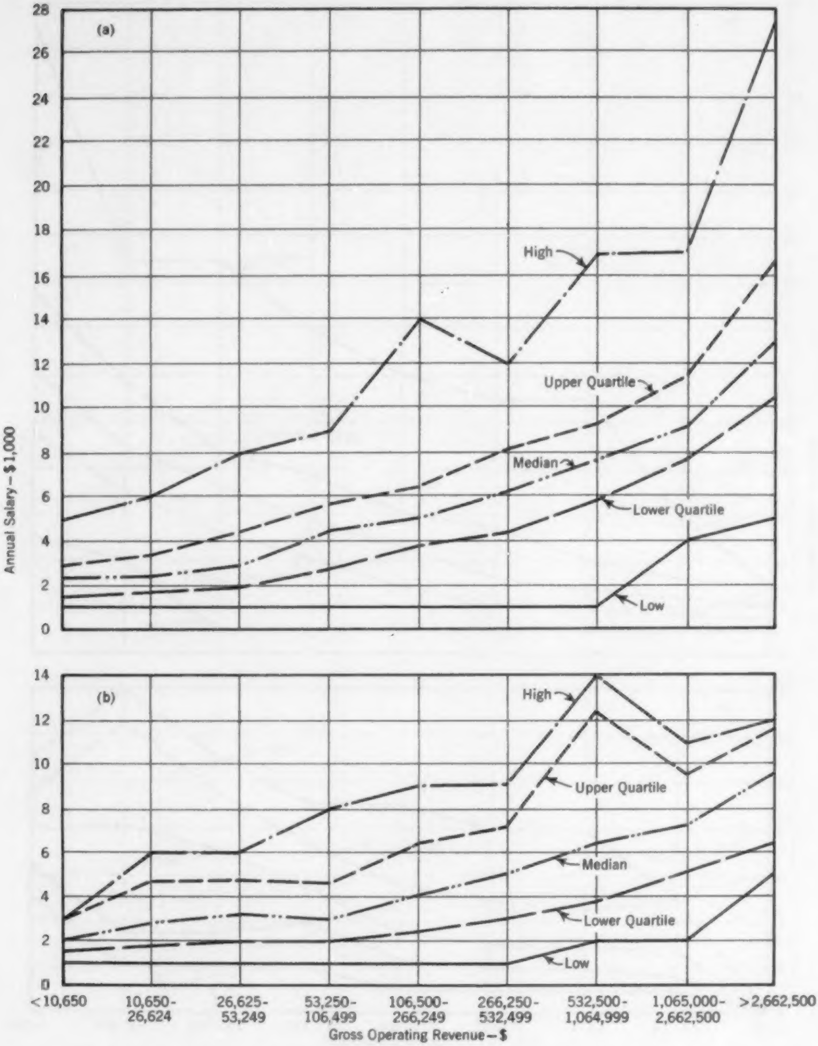

Fig. 6. Managers' Salaries by Gross Operating Revenue of Utility, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

privately owned utilities and six by publicly owned utilities. Of the six employed by publicly owned utilities, five reported directly to a local commission or board and one reported directly to the city manager. All of the six respondents in Canada receiving an annual salary of more than $9,500 were employed by publicly owned utilities. Of this group, two were under the public utilities commissions, two reported to a mayor and council, one reported directly to a public works department, and one reported to a local commission or board.

In the United States the average population served by publicly owned utilities was 53,100 and by privately owned utilities, 53,000, almost exactly the same. The average annual salary of all respondents, however, was $5,730 for managing publicly owned systems, as compared to $8,190 paid to managers of privately owned systems. As the average population served by both was practically the same, it appears that privately owned utilities pay their managers 43 per cent more than do publicly owned utilities. The higher salaries paid by privately owned utili-

TABLE 9

*1957 Annual Salaries by Composite Classifications**

Class	Annual Salary—$					
	Highest	Upper Quartile	Mean	Median	Lower Quartile	Lowest
United States						
1	6,000	3,070	2,270	2,370	1,680	1,000
2	9,000	3,630	2,800	2,680	1,840	1,000
3	11,000	4,670	3,280	3,030	2,010	1,000
4	14,000	5,610	4,130	4,100	2,560	1,000
5	14,000	6,340	5,010	4,940	3,550	1,000
6	15,000	8,080	6,200	6,130	4,360	1,000
7	18,000	9,210	7,680	7,610	5,620	1,000
8	18,000	11,490	9,270	8,980	7,120	1,000
9	27,000	15,420	13,380	12,170	9,770	2,000
Canada						
1	8,000	4,100	3,040	2,710	1,790	1,000
2	6,000	4,130	2,930	2,790	1,900	1,000
3	9,000	4,690	3,240	3,020	1,990	1,000
4	9,000	5,000	3,470	3,170	2,070	1,000
5	9,000	5,870	4,000	3,420	2,190	1,000
6	9,000	7,140	4,970	4,950	2,900	1,000
7	15,000	8,620	6,800	6,500	4,560	1,000
8	14,000	10,500	7,640	7,590	4,880	1,000
9	14,000	10,570	8,300	8,500	6,500	2,000

* Based on population served, water delivered, length of distribution mains, gross operating revenue, undepreciated historical cost, and the number of employees.

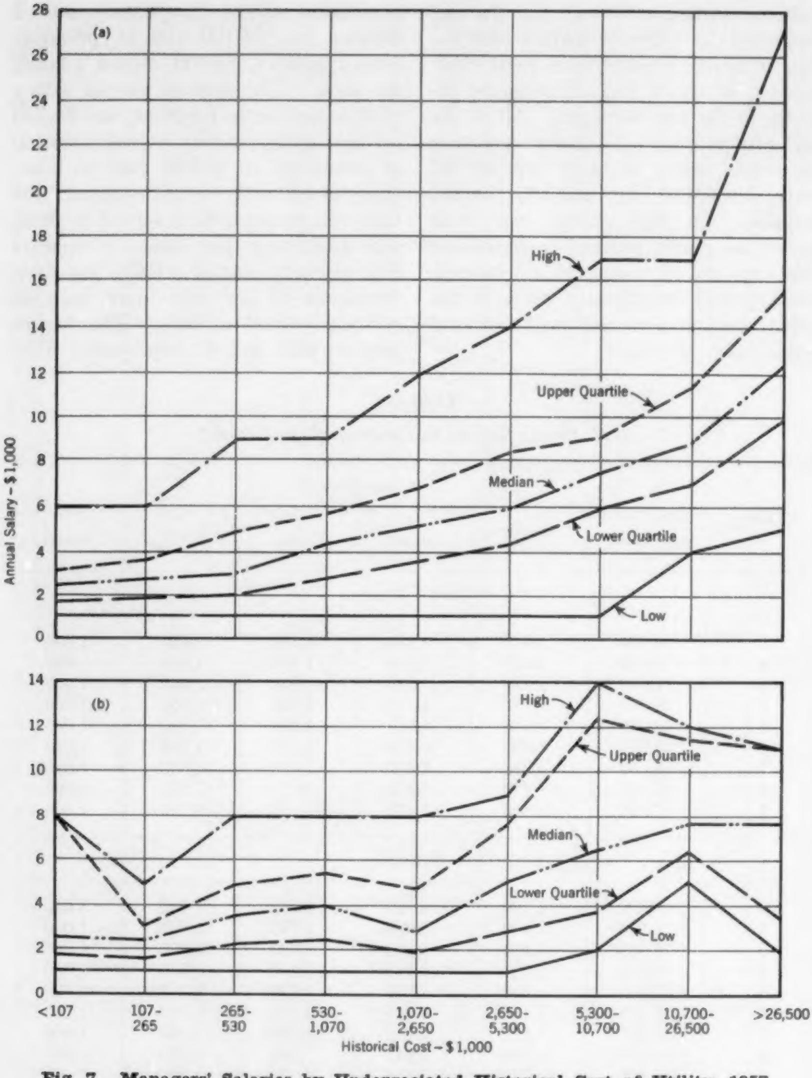

Fig. 7. Managers' Salaries by Undepreciated Historical Cost of Utility, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

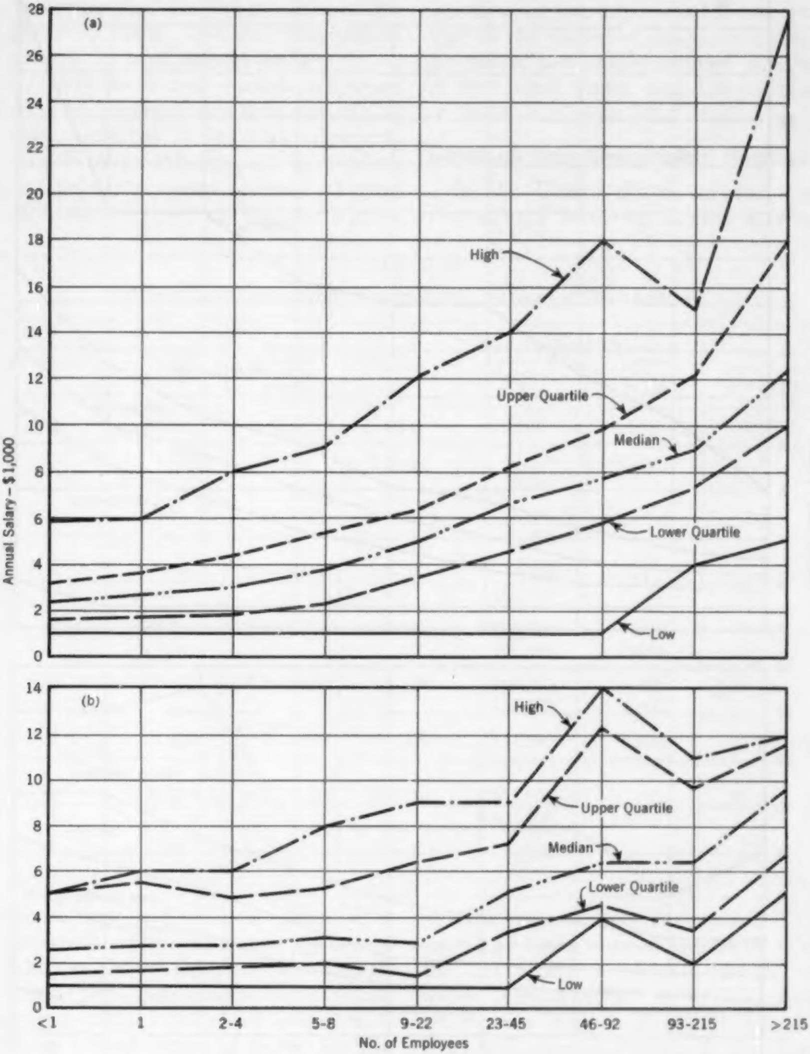

Fig. 8. Managers' Salaries by Number of Utility Employees, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities.

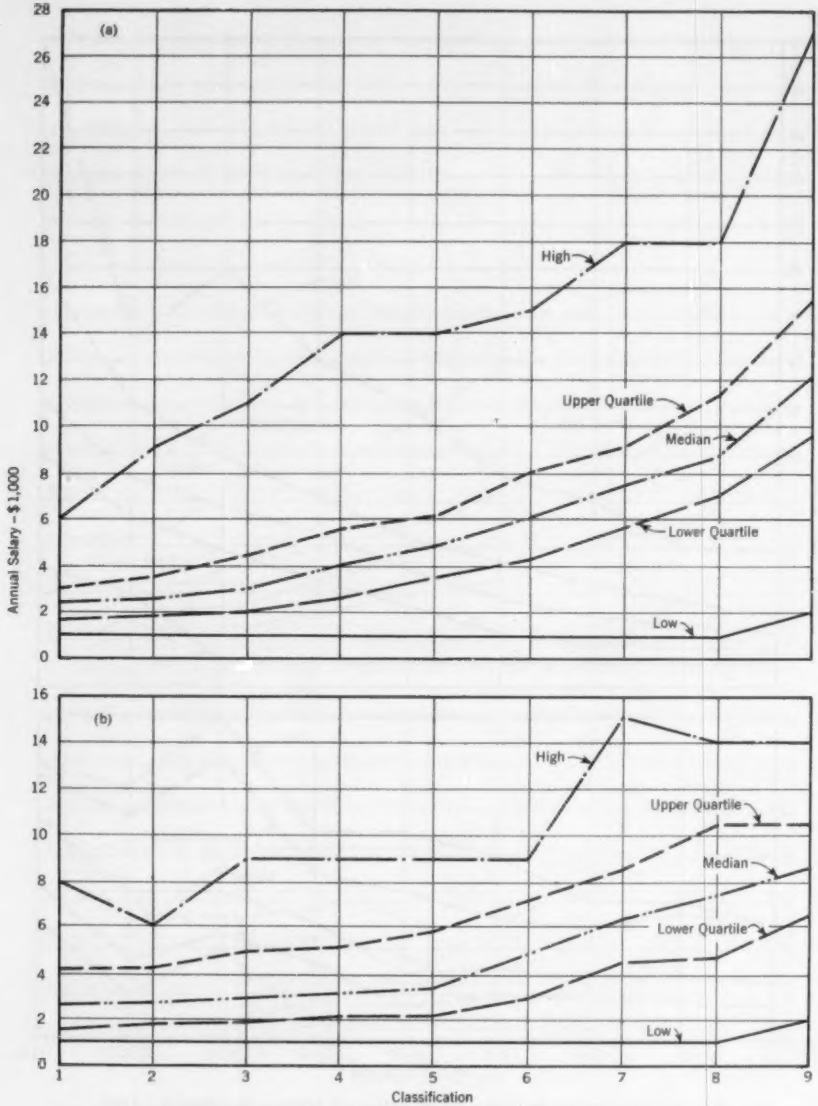

Fig. 9. Managers' Salaries by a Composite of Responsibility Variables, 1957

Part (a) gives data for United States utilities; Part (b) gives similar data for Canadian utilities. The curves are based on a composite of the data for Fig. 3–8.

ties are shown graphically in Fig. 10. It apears that the lowest salaries are generally paid by the mayor-and-council form of administration.

There were not enough responses from managers of privately owned Canadian utilities to draw any comparisons between salaries paid by publicly and privately owned systems. Figure 10 indicates, however, that the highest salaries are paid by local commissions or boards. The overall average annual salary of the respondents from Canada was $4,380, as compared to an overall average annual salary of respondents in the United States of $5,960 for like work—the average population of the respondent service areas in Canada being 43,300, as compared to 53,100 in the United States. The average population of the United States respondent service areas was 123 per cent that of the Canadian respondent service areas, and the managers' salaries in the United States were 136 per cent of those in Canada.

Earnings and Geographic Regions

In the United States, of the four respondents receiving annual salaries of more than $24,500, two were in Region 1 and two were in Region 9. Of the ten receiving annual salaries of more than $18,500 in the United States, two were in Region 1, two in Region 3, one in Region 4, and five in Region 9. Also, Fig. 2 shows that the highest average salary was in Region 9 ($7,710), the second highest was in Region 2 ($6,990), and the

TABLE 10

Breakdown of Managerial Responsibilities by General Classifications

Class	Population Served *1,000's*	Water Delivered Annually *mil gal*	Mains in System *mi*	Gross Annual Operating Revenue *$*	Historical Cost of Utility *$1,000*	No. of Full-Time Employees
1	<1	<49	<2.6	<10,650	<107	<1
2	1–2.5	49–121	2.6–6.4	10,650–26,624	107–265	1
3	2.5–5	122–244	6.5–12.9	26,625–53,249	265–530	2–4
4	5–10	245–489	13–25	53,250–106,499	530–1,070	5–8
5	10–25	490–1,224	26–64	106,500–266,249	1,070–2,650	9–22
6	52–50	1,225–2,449	65–129	266,250–532,499	2,650–5,300	23–45
7	50–100	2,450–4,899	130–259	532,500–1,064,999	5,300–10,700	46–92
8	100–250	4,900–12,500	260–650	1,065,000–2,662,500	10,700–26,500	93–215
9	>250	>12,500	>650	>2,662,500	>26,500	>215

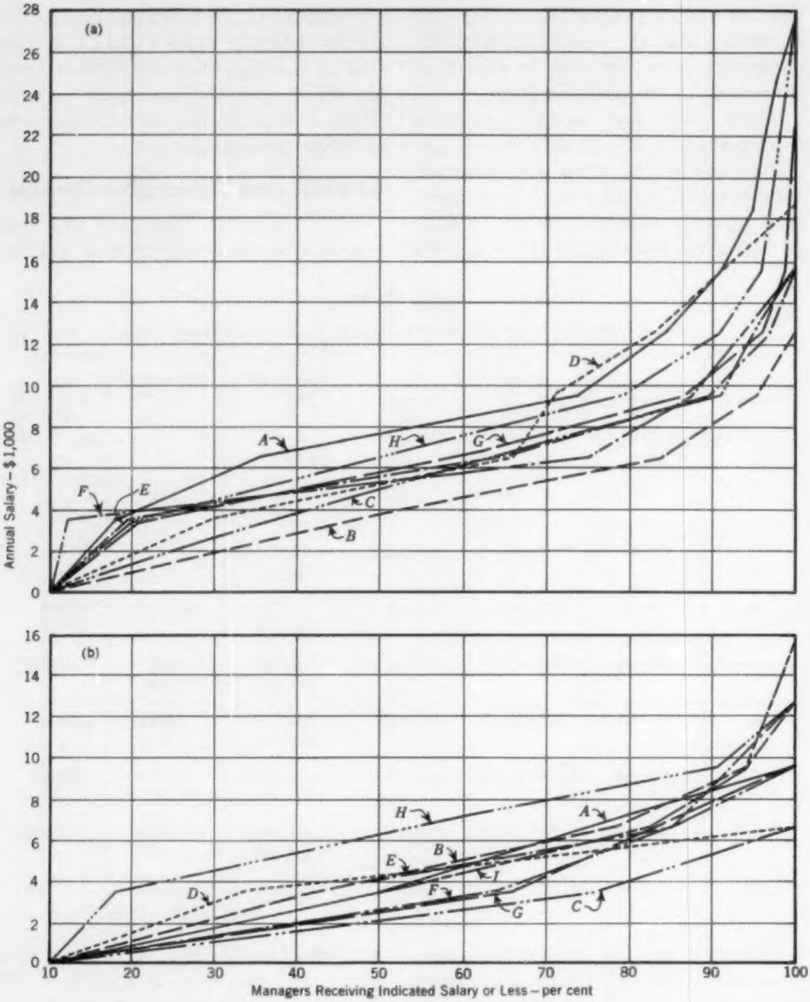

Fig. 10. Managers' Salaries by Utility Administration Type, 1957

Parts (a) and (b) give data for the United States and Canada, respectively. The curves represent data for managers reporting to the following persons or groups: A, *board of directors (private ownership);* B, *mayor or council;* C, *commissioner (council member);* D, *commissioner (not a council member);* E, *public works department;* F, *city engineer;* G, *city manager;* H, *local commission or board;* I, *public utilities commission.*

third highest was in Region 1 ($6,670). The highest average regional salary paid in Canada (Fig. 2) was in Region 3 ($4,780), and the lowest average regional salary was paid in Region 1 ($4,030).

Table 11 indicates some relationship between the salaries paid to the managers and the prevailing hourly-wage scale for unskilled labor in the community, but, as the size and location of the community are also related to the salary of the utility manager and the prevailing scale for unskilled labor, it is difficult to glean much significance from the relationship between hourly wages paid to unskilled labor and to the salaries paid to utility managers.

Duties in Addition to Management

The survey returns, as shown in Tables 12 and 13, indicated that a large number of water utility managers were required to perform duties other than water utility management. This is especially true of managers of publicly owned water utilities. Of the respondents managing publicly owned water utilities in the United States, 20 per cent were required to spend more than half of their time on other duties. In Canada the figure was 43 per cent. Ten respondents in the United States and eight in Canada from cities with populations larger than 100,000 spent more than half of their time on duties other than managing the water utility. In the same population range, 35 per cent in the United States and 75 per cent in Canada had some outside duties. In the United States, 61 per cent of the respondents in the publicly owned utilities and 26 per cent of those managing privately owned utilities had some additional duties. No doubt the additional duties of some of the managers of privately owned plants included managing other water utilities, but the number of managers of publicly owned plants so employed was negligible. In Canada, 74 per cent in publicly owned plants and 50 per cent in the privately owned plants had such outside responsibilities.

Although many water utilities are in small cities and the owners may consider it economical to have one man perform several jobs, it should be noted that only 21 per cent of the publicly owned utilities and 14 per cent of the privately owned utilities served areas with a population of less than 5,000. Surely any community with a population of more than 5,000 should be able to afford a full-time, capable manager for its water utility, even if such utility is a division of a department incorporating other activi-

TABLE 11

Managers' Salaries and Prevailing Hourly Wage Scale for Unskilled Labor

Managers Annual Salary $	Prevailing Hourly Wage for Unskilled Labor—$				
	0.5–1	1–1.5	1.5–2	2–2.5	2.5–3
No. of United States Managers					
<3,500	14	152	51	15	1
3,501–6,500	13	142	94	30	3
6,501–9,500	3	57	78	37	12
9,501–12,500	1	15	25	25	
12,501–15,500		4	11	7	7
15,501–18,500			3	2	1*
18,501–21,500				4	
21,501–24,500		1			
>24,500			1	1	2
No. of Canadian Managers					
<3,500	4	32	21		
3,501–6,500	3	22	14		
6,501–9,500		9	9		
9,501–12,500		2	3		
12,501–15,500			1		

* Prevailing hourly wage for unskilled labor was more than $3.

TABLE 12

Time Spent by Managers on Duties Other Than Water Utility Management

Manager's Working Time Spent on Other Duties *per cent*	United States Utilities				Canadian Utilities			
	Publicly Owned		Privately Owned		Publicly Owned		Privately Owned	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
0	292	39.2	58	74.2	29	25.7	2	50.0
1–5	35	4.7	2	2.6	2	1.8	0	0.0
6–10	33	4.4	1	1.3	3	2.6	0	0.0
11–15	20	2.7	2	2.6	1	0.9	1	25.0
16–20	25	3.3	0	0.0	2	1.8	0	0.0
21–25	40	5.4	1	1.3	5	4.4	0	0.0
26–50	151	20.2	2	2.6	22	19.4	0	0.0
51–75	111	15.0	6	7.7	33	29.2	0	0.0
76–99	38	5.1	6	7.7	16	14.2	1	25.0
Totals	745	100.0	78	100.0	113	100.0	4	100.0

TABLE 13

Relationship of Population Served to the Portion of Managers' Salaries Attributed to Duties Other Than Water Utility Management

Population Served *1,000's*	Portion of Manager's Salary Attributed to Other Duties—*per cent*								
	0	1–5	6–10	11–15	16–20	21–25	26–50	51–75	76–99
	No. of United States Utilities								
<1	10	5	1	0	0	0	6	8	5
1–2.5	20	6	1	2	3	5	16	14	4
2.5–5	14	7	1	0	1	3	16	11	7
5–10	42	1	7	4	3	9	25	20	8
10–25	59	7	7	7	8	6	31	22	10
25–50	57	4	7	6	4	8	28	19	6
50–100	65	3	4	3	2	5	16	13	4
100–250	49	3	4	0	2	5	9	8	0
>250	34	1	2	0	2	0	7	2	0
	No. of Canadian Utilities								
<1	0	0	0	0	0	0	1	1	0
1–2.5	2	1	1	1	1	0	5	3	2
2.5–5	8	1	0	0	1	2	1	9	3
5–10	4	0	2	0	0	0	5	5	3
10–25	5	0	0	0	0	0	5	5	3
25–50	6	0	0	0	0	2	3	4	4
50–100	2	0	0	0	0	1	1	1	1
100–250	2	0	0	0	0	0	1	5	0
>250	2	0	0	1	0	0	2	2	1

ties. Not to do so is definitely false economy.

It appears from this survey that a number of municipalities of more than 5,000 population are allocating insufficient funds for the employment of a full-time, competent manager, thus making it necessary for managers to spend a good portion of their time on other activities for either the same or some other employer. To a much lesser degree, this condition exists among privately owned water utilities.

The committee considers this a most serious situation and recommends that every effort be made to remedy it. The water supply industry is a highly specialized field, and the successful operation of a water utility serving more than 5,000 people requires the full-time services of a specialist. Many cities of less than 5,000 population have found it both desirable and economical to have the full-time services of a qualified water utility manager. The committee is convinced that a full-time manager is desirable for all water utilities and is essential when the population served exceeds 5,000.

Summary of 1957 Salaries

The salaries of water utility managers are extremely low by present standards. Of the respondents in the United States, 29 per cent received annual salaries of less than $3,500 per year. In Canada the figure was 46 per cent. The average annual salary for all respondents in the United States for managing the water utility only was $5,960; for Canadian respondents it was $4,380. Due consideration must, however, be given to the fact that the respondents reported only that amount received for their work as manager of the water utility; many of them had additional duties for which they no doubt received additional compensation. Therefore, the average salaries represent the amounts paid for managing the water utility alone but do not necessarily cover the total annual salaries received.

As an overall average, the respondents in the United States spent approximately 77 per cent of their work time in managing the water utility. In Canada, the figure was 60 per cent. If these percentages are applied to the average salaries of $5,960 and $4,380 quoted above, it would indicate that the total annual average income of the respondents was $7,740 in the United States and $7,300 in Canada. On the other hand, had all of the cities of less than 25,000 population been surveyed, the average salaries would have been much lower.

TABLE 14

Salaries Paid to Managers by Publicly and Privately Owned Water Utilities

Annual Salary $	Publicly Owned Utilities *per cent*	Privately Owned Utilities *per cent*
United States		
< 3,500	30	19
> 3,500	70	81
> 6,500	34	64
> 9,500	12	26
>12,500	5	15
>15,500	1	9
Canada		
< 3,500	46	50
> 3,500	54	50
> 6,500	19	25
> 9,500	5	0

It might be noted that a survey made by the National Society of Professional Engineers reveals that the median 1958

salary of registered professional engineers in the United States was $10,000. This is of more than passing significance, because of the close relationship of engineering with the water supply industry.

A breakdown of the respondents managing publicly and privately owned water utilities is given in Table 14.

From Table 15 it is evident that in the United States the privately owned utilities also generally provide their managers with more fringe benefits. Only in paid holidays, vacations, and paid sick leave do the publicly owned utilities take a very small lead. Privately owned utilities more often provide such fringe benefits as a car for personal use and life, hospital, and surgical insurance. Because of the small number of privately owned plants reporting, a similar comparison for Canada is not significant.

TABLE 15

Manager Fringe Benefits Provided by Privately and Publicly Owned Utilities

Benefit	United States Utilities				Canadian Utilities			
	Publicly Owned		Privately Owned		Publicly Owned		Privately Owned	
	No.	Per Cent of Total	No.	Per Cent of Total	No.	Per Cent of Total	No.	Per Cent of Total
Paid holidays	654	87.8	64	86.5	97	86.6	3	75.0
Annual vacation	685	92.0	68	91.9	99	88.4	3	75.0
Sick pay	567	76.1	48	64.9	74	66.1	3	75.0
House	37	5.0	5	6.7	6	5.4	0	0.0
Car (personal use)	191	25.6	46	62.2	29	25.9	0	0.0
Insurance								
Life	151	20.3	51	68.9	32	28.6	1	25.0
Hospital	241	32.3	48	64.9	59	52.7	0	0.0
Surgical	137	18.4	41	55.4	44	39.3	0	0.0
Pension	368	49.4	46	62.2	79	90.1	2	50.0
Telephone (home)	123	16.5	31	42.0	35	31.2	1	25.0
Technical society dues	296	39.7	40	54.0	29	25.9	1	25.0
Cash bonus	34	4.6	16	21.6	11	9.8	0	0.0
Other	62	8.3	25	33.8	8	7.1	0	0.0
None	30	4.0	5	6.7	6	5.4	0	0.0
Totals	745		74		112		14	

Salaries in Other Industries

The management of a water utility differs very little from that of any other industrial plant, especially as far as responsibilities, training, and basic qualifications are concerned. It is logical, therefore, to compare the salaries paid to water utility managers with those paid for similar positions in other industries, particularly in other utilities.

In September 1957, the privately owned gas utilities in the United States were sent circulars to obtain information on the book value of their utilities as of Jan. 1, 1957, and the salary of the vice-president in charge of operations—the latter being the position generally comparable to that of man-

ager in a water utility. Replies were received from 77 gas utilities. The results of this survey are shown in Table 16.

TABLE 16

Salaries of Vice-Presidents in Charge of Operations of Privately Owned Gas Utilities

Book Value *$1,000*	Avg Annual Salary *$1,000*	Salary Range *$1,000*
<1,250	6.7	5.4–8.4
1,255–2,500	9.7	6.7–15
2,505–5,000	9.4	6.8–12
5,005–25,000	12.8	8.7–18
>25,000	22.8	11.5–35

A document issued in June 1957 (*1*) reports the annual salaries of the managers of publicly owned electric utilities in the United States in relation to: [1] annual electric operating revenues, [2] annual kilowatt-hour sales, [3] generating capacity (in installed kilowatts), [4] number of customers, and [5] number of employees. This report did not relate the salaries of executives to book values of utilities. It has, however, been established that the book value of an electric utility is usually approximately five times its annual operating revenue. Therefore, the estimated book values shown in Table 17 were obtained by multiplying the annual operating revenues by five. No doubt some injustices were done by this method, but by and large the figures shown should be sufficiently accurate for an investigation of this nature.

It is obvious from Table 18 and Fig. 11 that managers of water utilities are paid considerably less than managers of electric and gas utilities for positions of like responsibility. A study of the average annual salaries set forth in Table 18 indicates that electric utilities pay their managers 35–59 per cent more than water utility managers are paid in plants of similar book value ranges. The difference is even more pronounced in gas utilities, which apparently pay their managers 57–91 per cent more than do water utilities. It should also be noted that the electric plants surveyed were all publicly owned and the gas utilities were all privately owned. There are relatively few publicly owned gas plants. No doubt, if publicly and privately owned plants in both the electric and gas utilities had been included in the surveys, the average salaries of managers of both would have been more nearly alike. In interpreting this comparison it should be kept in mind that, on the average, 23 per cent of the water utility manager's total annual salary is derived from duties other than water utility management.

TABLE 17

Salaries of Managers of Publicly Owned Electric Utilities

Operating Revenue *$1,000*	Estimated Book Value *$1,000*	Salary Range *$1,000*	Avg Annual Salary *$*
<250	<1,250	4.9– 8.5	5,526
251–500	1,255–2,500	5.9– 8.6	7,581
501–1,000	2,505–5,000	7.3–10.2	9,085
1,001–5,000	5,005–25,000	8.6–14.0	11,478
>5,000	>25,000	15.8–20.0	17,456

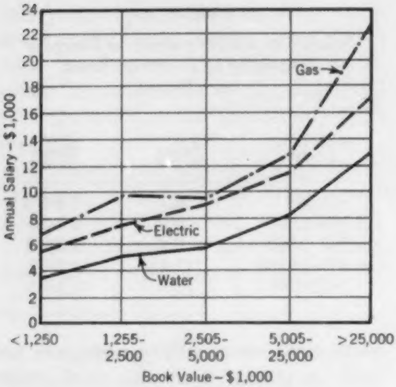

Fig. 11. Comparison of Managers' Salaries in Water, Gas, and Electric Utilities, According to Book Value of Utility

Water utility managers are shown to receive consistently lower salaries than do their counterparts in other utilities.

An article by Munson (*2*), based on an annual survey of top management compensation, reported on 642 companies and eighteen different industries. Public utilities were represented by 34 different operating companies. The following is taken from that article; Charts 1–3 are reproduced here as Fig. 12–14.

Chart 1 plots the total compensation of highest paid executives with total assets of their companies. Thus, each utility company surveyed appears as a dot on the chart. A line of best fit is calculated and drawn through the dots. Superimposed on the chart for comparison is a dotted line representing the corresponding line of best fit for all industries included in the survey. It is apparent from Chart 1 that utility companies do not pay their chief executives as much on the average as companies of comparable size, in terms of total assets. In making this comparison, however, it must be recognized that different industries have different traditions and different compensation practices.

Chart 2 sets forth a similar analysis, but substitutes profits for total assets in the analysis. In terms of profits, the chief executives of utility companies still receive less total compensation than their counterparts in other industries. It is noteworthy, however, that this disparity tends to narrow in the case of companies with higher profits.

Chart 3 shows that the compensation of chief executives in the utility industry compares more favorably to companies of equivalent size measured in terms of sales volume.

Indeed, the line of best fit for utilities comes fairly close to that for all industries. This reflects the fact that changes in top-management compensation generally trends in profits rather than sales. Sales were typically up and profits down for the companies surveyed in 1957, but both were up for utilities.

TABLE 18

National Averages of Annual Salaries of Managers of Electric, Water, and Gas Utilities by Book Value of Utility

Estimated Book Value *$1,000*	Managers' Annual Salary—$								
	Average			Lowest			Highest		
	Electric	Water	Gas	Electric	Water	Gas	Electric	Water	Gas
<1,250	5,526	3,500	6,700	4,858	1,000	5,400	8,517	9,000	8,400
1,250–2,500	7,581	5,220	9,700	5,897	1,000	6,700	8,562	12,000	15,000
2,500–5,000	9,085	5,720	9,400	7,275	1,000	6,800	10,250	14,000	12,000
5,000–25,000	11,478	8,160	12,800	8,564	1,000	8,700	14,013	17,000	18,000
>25,000	17,456	12,900	22,800	15,840	5,000	11,500	20,066	27,000	35,000

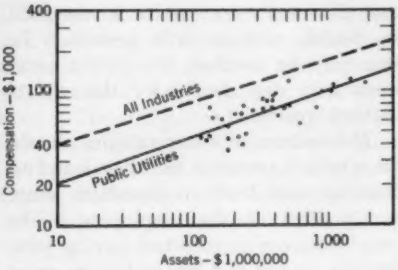

Fig. 12. Managers' Salaries in Public Utilities as Compared to Other Industries, According to Assets

The compensation of the second-, third-, and fourth-highest-paid executives in the public-utility industry continues to lag further behind the top man than . . . in the other industries surveyed:

	Compensation Expressed as Percentage of Chief Executive's	
	All Industries	Public Utilities
Second-highest-paid executive	69	63
Third-highest-paid executive	57	49
Fourth-highest-paid executive	52	45

An interesting contrast to this relatively unfavorable showing of utility executives is provided by published data on wage earners. Bureau of Labor Statistics data on the annual gross earnings of production and other nonsupervisory workers in the same industries covered in the McKinsey survey show that utility workers fare somewhat better than average:

	Average Annual Earnings $
All industries	4,445
Public utilities (six highest)	4,912

It will be noted that the McKinsey survey included only privately owned utility companies; doubtlessly these were predominantly electric and gas utilities, as only 34 different operating companies were considered. Because electric and gas utilities pay their executives more than do water utilities, and because industry in general pays executives more than do the electric and gas utilities, it is apparent that the water utility manager is generally woefully underpaid by any standard. A similar comparison could not be made for Canada owing to a lack of information. There is nothing to indicate that the situation in Canada is materially different from that in the United States, however.

Implications of Survey

This report demonstrates the extremely low and inadequate salaries being paid to managers of water utilities. They are inadequate regardless of the yardstick used for comparison. It follows that the salaries paid to most other water utility personnel are, of necessity, relatively low also.

What does this mean to the industry as a whole and to its customers? It means that the most essential industry of today is, in many instances, being manned by unqualified personnel, because its low-wage policy simply cannot attract or retain qualified people in today's competitive labor market. There are a number of qualified individuals so dedicated to their trust that

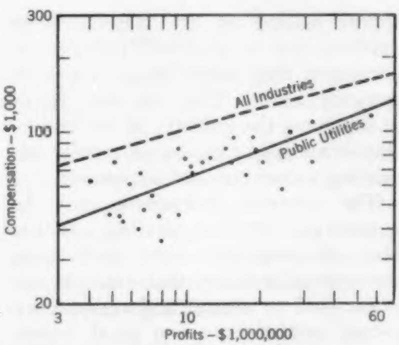

Fig. 13. Managers' Salaries in Public Utilities as Compared to Other Industries, According to Profit

they remain in spite of this condition, but is it right to expect them to continue to do so? Even the most dedicated become discouraged after a time. The low-wage policy may well account for the precarious position in which many water utilities find themselves today. In 1953, 1,073 water utilities in the United States had to curtail water service because they were unable to meet the demand. This affected 24,000,000 people and is a serious indictment of the industry and its personnel.

The industry can expect to deteriorate further as long as it follows a low-wage policy. Because poor wages

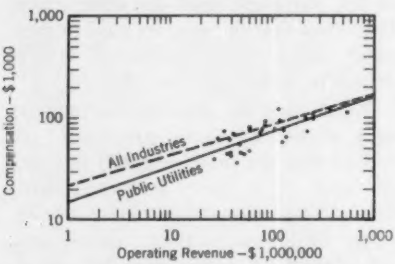

Fig. 14. Managers' Salaries in Public Utilities as Compared to Other Industries, According to Operating Revenue

appeal neither to the better college graduate nor to qualified, experienced personnel, they naturally go into more lucrative fields. This can only result in depriving the industry of the leadership it needs in this day of rapidly advancing techniques and expansion.

The owner's investment may be jeopardized by low salaries. It has been demonstrated time and again throughout industry that realistic salaries, paid to attract and retain competent employees, are a good investment and that it is dangerous to follow any other policy. Sooner or later the community will be deprived of the good and efficient water service so essential to health, welfare, and growth. In one way or another, the public must eventually pay dearly for this shortsighted policy.

The owners of water utilities should be vitally interested, for they stand to lose far more from an unrealistic wage policy than do the employees. The employees can go to better paying jobs, but the owner and his customers must live with the problem. Owners, customers, and regulatory bodies must realize that water utility rates must be adequate to insure good service and continued advancement—that is, adequate to pay the salaries that will interest the people who are qualified and who can insure good service and continued advancement. The industry has a responsibility to the people to apprise them of the value and cost of good water service. In many communities the industry is already reaping the disastrous results of the "cheaper than dirt" policy.

Recommended Qualifications

The water industry is facing the greatest challenge of its existence, with plants that, for the most part, are not up to par. The future will require tremendous expansion. To meet that challenge, the industry will need, among other things, well qualified managers. The committee has tried to point the way by setting up recommended qualifications for managers as a first step toward that end.

The results of the survey on qualifications and duties of water utility managers might be summarized as follows: [1] their general educational qualifications are fair; only 16–19 per cent have less than a high school education; [2] their responsibilities are not too clear cut; too many managerial duties are performed by others; and [3] their experience seems reasonably good.

Using the data on basic qualifications and the extent of duties, the committee attempted to correlate educational qualifications with recommended salaries. The committee believes that the industry needs guidance and leadership in this area if it is to meet present and future challenges. The following recommendations are therefore offered:

1. That all water utility managers have at least a high school education
2. That any water utility serving a population of 5,000 or more should have a full-time manager
3. That a utility serving a population of 10,000 or more should have a full-time graduate engineer (or his equivalent) in its employ, preferably a registered professional engineer
4. That any utility serving a population of 25,000 or more should have a college graduate (or his equivalent) as its manager.

High School Graduate

High school graduates are quite available today, and there is therefore no necessity to accept anyone with less education. Less back power and more brain power are needed to operate the more complicated equipment being used today. High school graduates are also much more likely to take advantage of in-service training courses than are nongraduates.

Graduate Engineer

One of the great challenges to the water utility is to keep its facilities in

TABLE 19

Recommended Annual-Salary Ranges for Water Utility Managers, 1959

Class	Annual Salary *$1,000*		Ranges of Responsibility					
	Min.	Normal Limit	Population Served *1,000's*	Water Delivered to System Annually *mil gal*	Mains in Distribution System *mi*	Gross Annual Operating Revenue *$*	Historical Cost of Utility *$1,000*	No. of Full-Time Employees
1	3.0	6	<1	<49	<2.6	<10,650	<107	<1
2	3.9	8	1–2.5	49–121	2.6–6.4	10,650–26,624	107–265	1
3	4.8	10	2.5–5	122–244	6.5–12.0	26,625–53,249	265–530	2–4
4	5.4	12	5–10	245–489	13–25	53,250–106,499	530–1,070	5–8
5	6.4	14	10–25	490–1,224	26–64	106,500–266,249	1,070–2,650	9–22
6	7.5	16	25–50	1,225–2,449	65–129	266,250–532,499	2,650–5,300	23–45
7	9.0	18	50–100	2,450–4,899	130–259	532,500–1,064,999	5,300–10,700	46–92
8	11.0	20	100–250	4,900–12,500	260–650	1,065,000–2,662,500	10,700–26,500	93–215
9	15.0	29	>250	>12,500	>650	>2,662,500	>26,500	>215

good repair to meet present commitments and to build them up to meet the future needs of the community it serves. This challenge can best be met only if a qualified engineer is available on a full-time basis. All utilities need engineering service from time to time. The committee believes that any utility serving a population of 10,000 or more needs such service continuously. There is no reason why the engineer may not also be the manager.

College Graduates

The problems and responsibilities that confront the manager of a water utility serving 25,000 or more people require that he exercise sound judgment, that he think clearly, and that he be able to work well with others. It is equally important for him to be able to speak well and win public support for the utility. These things can be done well only by a college-trained man, or his equivalent, who has been prepared for such responsibilities. Such a man may or may not have engineering training.

Recommended Salaries

In order to give the industry a yardstick to work by in establishing realistic salary policies for water utility managers, the committee has set up classifications of responsibilities with corresponding recommended salary ranges (Table 19). The salary ranges in Table 19 are based on a number of factors, including the survey of water utility managers, the survey of salaries of gas utility managers, information concerning salaries paid to electric utility managers, study of salaries paid in industry generally, normal increases granted since the time of the surveys, and general economic conditions. It is realized that salary policies cannot be adjusted overnight. The recommended salary ranges will have to be adjusted from time to time to allow for changed economic conditions, overall wage level changes, and general improvements in the quality of personnel.

To use Table 19, one should select the classification that most nearly corresponds to the responsibilities of the manager; the recommended salary range appears under that classification. Most water utilities will fall, generally, within one of the nine classifications. Certain areas of responsibility, however, may fall outside the selected classification; these should be taken into account in the selection of the proper salary range. Such factors as experience, length of service, and special abilities determine the proper salary level within the range. Judgment is required in the use of all such generalized tables, but this table should be valuable to both employer and employee in establishing fair and equitable salaries and to the industry in improving its leadership.

Acknowledgment

The committee gratefully acknowledges the cooperation of members of the Association staff, especially Secretary Raymond J. Faust; of the state sanitary engineers who provided the names of local utility managers and aided in making the survey a success; and of the managers of gas and water utilities who cooperated in the survey.

References

1. Survey of Executive Salaries and Fringe Benefits of Local Publicly Owned Electric Utilities. Document 57-S-02, American Public Power Association, Washington, D.C. (Jun. 1957).
2. MUNSON, L. S. Utility Executives' Compensation. *Pub. Utilities Fortnightly*, **62**:10:742 (Nov. 6, 1958).

Wisconsin Drinking Water Law and Current Ground Water Problems

A. Allan Schmid

A contribution to the Journal by A. Allan Schmid, Asst. Prof., Dept. of Agricultural Economics, Michigan State Univ., East Lansing, Mich., and formerly Research Asst., Univ. of Wisconsin, Madison, Wis.

WISCONSIN was one of the first states to pass a law regulating well drilling to safeguard the quality of drinking water. Since 1919, the Wisconsin statutes have provided the state board of health with broad powers for the regulation of well construction and water systems related to public and institutional supplies. The need to supervise private water supplies was also recognized, for the number of typhoid cases in rural areas was greater than that in municipal areas with supervised wells. Finally, in 1935, Chapter 162 of the statutes was passed. This allowed the board of health to supervise all wells supplying water used for human consumption.

In the early days, when the settlers came to Wisconsin to build homes and start farms, the supply of safe water was no problem. A farm spring was a source of clear, cold water that served to refrigerate food and provide drink for settlers and livestock. This situation changed with the growth of the population. When people began living closer together and industry began to grow, a water supply problem was created. Supervision and planning were needed to insure safe water.

This study of the economic and political aspects of the passage and administration of the Wisconsin law may be valuable as a guide for other states that do not yet have adequate regulations on drinking water, and as a procedural guide for the several humid states now attempting to revise laws regulating the allocation of water among competing users. Existing regulations on water use are repeatedly becoming inadequate because of increased demands.

Content of the Law

Chapter 162 of the Wisconsin statutes specifies the powers of the state board of health to prescribe and enforce minimum reasonable standards and rules for procuring and protecting drinking water for human consumption. An important part of this law was the provision requiring the registration of well drillers. Specifically, the powers of the state board of health are defined in the law (162.01) as follows:

> The state board of health shall . . . determine, and after a public hearing, prescribe, publish, and enforce minimum reasonable standards and rules and regulations for methods to be pursued in the obtaining of pure drinking water for human consumption and the establishing of all safeguards deemed necessary in protecting the public health against the

hazards of polluted sources of impure water supplies intended or used for human consumption, including minimum reasonable standards for the construction of well pits. It shall have general supervision and control of all methods of obtaining ground water for human consumption, including sanitary conditions surrounding the same, the construction or reconstruction of wells . . . and shall do and perform any act deemed necessary for the safeguarding of public health.

The detailed regulations prescribed by the board of health, after a public hearing was held, are contained in Chapter H 55 of the Wisconsin Administrative Code.

Passage of the Law

The state board of health played an important role in the introduction of the legislation; the law was passed on the first attempt. The board was concerned with the high incidence of unsafe water samples submitted to the state laboratory of hygiene. In 1935, 70 per cent of all the samples submitted were found to be unsafe. Fortunately, Wisconsin was one of the few states that provided free bacteriologic analysis of water samples. Through the years, records of these analyses proved that a serious water sanitation problem existed. The records were important in educating the legislature on the nature of the problem and convincing it of the need for action. If this specific information had not been available, it would have been difficult to make people aware of the situation. A private citizen is usually satisfied if he has been getting water from his own well for years with no apparent harmful effects. Another factor that served to point up the problem and arouse public support for the law was a survey of school wells in the state, which showed that many were unsafe.

Regulation of Wells

The law, as originally enacted, requires the registration and regulation of well drillers working on wells that will supply water for human consumption. This classification includes the wells of utilities and the private wells found in rural areas. The statute does not regulate wells supplying water for livestock, although this water may later be used for human consumption. Also, a farm may be sold, and the new owner might use for his own supply, water formerly given to livestock. If livestock wells were regulated, a farmer, in addition to improving his personal well, would have to pay the expense of improving his livestock well, in order to meet the minimum standards. Perhaps this consideration was the reason that livestock wells were not included in the law, for such a provision might have aroused additional opposition to its passage.

Any penetration into water-bearing strata may be a source of contamination of an underground supply, but drilling in conjunction with mining operations is not regulated. Eventually, perhaps, all drilling that might affect an underground supply will have to be controlled.

Administration of the Law

The administrative code prescribed by the state board of health to govern well construction has been amended several times. The first edition of the code was published in 1936, and amendments and revisions were made in 1939, 1951, and 1953. In 1951, a major attempt was made to clarify the code, which was difficult to interpret and, therefore, the basis for many conflicts. Formerly, the code presented the requirements for well drill-

ing in a narrative fashion. The code was revised and the requirements presented in tabular form so that drillers could easily determine what was expected of them. Statute drafters and administrators should note that simply from the use of tables instead of long accounts difficult to read, much opposition to the statute and the possibility of future conflict resulting from misinterpretation were eliminated. Equally important were the provisions of the statute that authorized, in conjunction with administration, the education of the public in the merits of the law.

By 1953, some well drillers criticized the board, claiming that it was not doing its job and that many violations were occurring. The board brought in another staff member and began to suspend drillers who had violated code provisions. Even today, after various revisions of code regulations have been made, there are problems of interpretation. These problems are ever present when rules deal with highly technical material, and when drillers who must interpret the rules are not familiar with the terminology used and the related technicalities.

Well construction requirements are adaptable to the geologic and ground water conditions existing at the site of a well. To this extent, the rules may be applied to a specific area. They are not fixed statewide without regard for the specific technical conditions involved. Problems concerning exceptions to the rule still arise. For example, the requirements for well casings in areas where the water-bearing formation is limestone lying relatively close to the surface, prescribe that the well must be cased to a depth of 40 ft. In some areas of the state, compliance with this requirement puts the casing down below the water-bearing strata, and thus no water can be pumped. This is only one instance when a code must be flexible enough to adapt to a specific situation. The Wisconsin code does provide for such flexibility.

There are only two men in the central office of the board of health devoting full time to the administration of the statute. Eight engineers and six sanitarians in the district offices attend to the law at different times. In addition, there are central office milk sanitarians and district hotel and restaurant inspectors who give valuable assistance. The budget of the well-drilling division of the board is approximately $25,000 per year.

Driller Monopoly

After years of observing the effects of the water law, the Wisconsin Well Drillers Association felt that the law was too lenient about granting permits to drillers. Anyone could get a permit upon application and payment of a fee, even if he had no experience or equipment. In 1953, the legislature passed an amendment (162.04 [3]) that specified 2 years of experience with a well driller registered in Wisconsin as a condition for the granting of a permit. This largely satisfied the state's well drillers and, at the same time, gave them an element of monopoly control over newcomers to the business. Although it was unplanned, one of the most stringent effects of this experience requirement was that it prohibited out-of-state drillers from operating in Wisconsin. Experienced and highly qualified drillers from another state, who had not operated in Wisconsin before the passage of the amendment, cannot now get a permit unless they are in a position to work 2 years for a registered driller.

Minimum and Ideal Standards

One of the critical features of well installations is the surface seal between the pump and the well casing. Improper pump and pipe installations can make a good well unsafe by leaving an opening through which contaminated matter may enter. To insure the construction of a completely safe well, it is important that standards and registration requirements be established for pump installers as well as for well drillers. Such a provision (162.04) was added to the Wisconsin statute in 1953, although the controversy between drillers and pump installers about who was to blame when a well proved to be unsafe was evident at the time the original law was passed in 1935. As was mentioned for the nonregulation of livestock wells, perhaps the reason for the delay in regulating pump installations was to facilitate the passage of the 1935 statute controlling well drilling.

The controversy over the regulation of well pits is a more concrete example of the acceptance of minimum standards instead of the ideal standards formulated by technicians. The 1936 and 1939 editions of the well code allowed the construction of well pits. On Jul. 27, 1951, the code was revised to prohibit the construction or reconstruction of well pits on farms producing milk for sale. Although the code made no reference to existing pits, this revision came close to enforcing ideal sanitary conditions. The dairy farmers objected, because the abolition of well pits would necessitate costly aboveground well houses that had to be heated. A number of hearings were held in 1952, at which time farm organizations and business groups suggested changes.

In 1953, the legislature passed an amendment to Chapter 162 of the statutes providing that the well code must include minimum reasonable standards for the construction of well pits. On Apr. 10, 1953, the board of health published new regulations that allowed pits if a permit was obtained for them. Such a permit is granted where a reasonably safe water supply is assured. The board allowed a 3-year compliance period for the nonconforming owners of well pits.

This was a compromise that allowed minimum reasonable standards instead of an ideal standard. Perhaps, as the poorer pits are abandoned in the future, the more stringent regulation will be reinstated.

Group Interests

To understand the political processes and the resulting law, it may be helpful to mention some of the groups of people who have interests in the water law and to examine some of the issues behind these interests. From the opposing groups come the compromises that make for a workable law.

Well Drillers

The well drillers themselves make up the main group involved. If there are no minimum standards, well drillers can undersell competitors by cutting down on the quality of the work. Cheaper materials, such as lighter gage casings, can be used. A farmer is tempted to take the lowest bid on a well, for he is probably unaware of all the elements involved in the construction of a good well. To the layman, a well is satisfactory as long as it supplies clean-looking and apparently safe water. But if minimum standards of well construction and

minimum requirements for well driller registration are enforced, a well owner, though he is still not certain of getting the full return on his investment, will, at least, be paying for a product that meets the minimum standards.

It is difficult, however, to get the public to support a statute on well drilling. A farmer who has been getting "good" water out of his old, dug well for years, may feel that a law setting up minimum requirements is the height of technical idealism. People are likely to believe that odor-free, crystal clear, cold water without unpleasant tastes is also safe water. As mentioned earlier, the public health data on the frequency of unsafe water samples were an important factor in defining the problem. Legislators are sensitive to this kind of information.

Probably the chief reason that well drillers opposed the regulation was because of the requirement that certain hydrologic and geologic data on each well drilled be given to the state board of health. This requirement is not a part of the statute, but it is a part of the administrative code that requires a formal report on well construction, as prescribed by the board of health. The well drillers argue that their private knowledge of the geology of their area, accumulated after many years of experience, is an essential part of their business, and to have to give up this information to others is unfair. If a well driller does not know what geologic formations he is likely to encounter while drilling a well, he must include the costs resulting from this uncertainty in his overall price. Therefore, the local driller who knows his area has a price advantage over neighboring competitors who are less familiar with it.

This argument was much more valid in times past than it is today. Through the fine work of USGS and state geologic surveys, reliable geologic information is available to anyone. The local driller, therefore, really has no monopoly on the data of his area. There may exist, however, certain geologic peculiarities in particular areas. If detailed log data of these places were provided by a well driller and made public, it would help a competitor who was not aware that an unusual problem existed. But this does not happen often. To accommodate the drillers, the Wisconsin State Board of Health does not make the log data supplied by drillers available to the general public. The data are available to USGS and to other reseachers, but they are not published. Also, such data are helpful to the state board of health for supervisory purposes. It is impossible for the board's staff to inspect every well; log data give the board a basis for determining whether the well construction requirements for a particular geologic formation have been followed.

Drillers have much to gain from close cooperation with state geologists who can give them valuable technical advice when they are bidding on a contract. For example, the geologists can show the drillers the areas in which particular contract specifications might be impossible to fulfill. They can point out certain risks involved, and the driller can adjust his bid accordingly. Also, when the drillers are on a job and difficulties arise, the geologists can be of help. Of course, there are areas in which geologic conditions vary so widely that the only resort is to drill a test well. The state board of health and state geolo-

gists can also help defend a driller who has tried his best to meet all requirements but who, because of factors beyond his control, is being criticized for drilling a well that is unsafe.

Important to the success of the Wisconsin statute is the cooperation of the well drillers among themselves. Even before the law was passed, drillers worked through their own association in an orderly manner, overcoming the jealousies that arise from the keeping of trade secrets. In the early days, local drillers did not help a rival if he was thought to be drilling in an area outside his own. The efforts of the association overcame these suspicions and resulted in more cooperation among drillers. The well drillers realize that if one of them drills an unsafe well, it reflects on all of them. Thus, they have a real interest in rules that protect those who try to do a good job against the few others who do substandard work. It is important to note that a critical factor in the formation of the water law was the established practices of drillers that later became codified and modified to conform to public interests.

Dairy Industry

There are several other groups that have an interest in the regulation of well drilling. The dairy industry in general is very concerned about the availability of safe water. Of course, when regulations affect a person's finances, the general good is more difficult to see, as when a dairy farmer is forced to abandon an old, dug well that may have been poorly located and incur the cost of a new well. In Wisconsin, between 1953 and 1955, Grade A dairy farmers thought that the state board of health requirements were causing them a lot of unnecessary expense. At the time, the farmers were confused by the fact that the Grade A administrators of the Chicago milkshed realized the need for safe water and started to evaluate the water supply requirements of the milk ordinance and code of USPHS, which were revised in 1953 and which had requirements similar to the Wisconsin statute. Today, when the Grade A administrators enforce the federal requirements, a reasonable state statute on well drilling should not affect the average dairy farmer.

Manufacturers

Manufacturers of well equipment are probably not too concerned about the water law. A standardization of the kinds of equipment required, however, should be beneficial to manufacturers. It does away with the need to stock many varieties of supplies, such as well casings. Even more significant is the fact that the regulations increased the drillers' demand for better quality equipment.

Industry in General

Industrial water users in general support the law. Food processors, especially, cannot risk the chance of a contaminated water supply. Industrial wells whose waters are not used for human consumption are not regulated under the Wisconsin statute. They are, however, subject to review under another statute, also administered by the state board of health, regulating high-capacity wells. The board has the right to condition a well construction permit and try to avoid the possibility of contamination. Where a high-capacity well (100,000 gpd) is drilled, the well owner must apply for a permit.

Recreational Areas

Recreational areas also have an interest in safe water, for tourists naturally expect it. If word gets out that a recreational facility does not have safe water, its business can be ruined. An example of this occurred in Door County, Wis., several years ago. The state board of health knew of the unsatisfactory water conditions in a particular area, but the persons responsible did not cooperate with the board in remedying the situation. Everything came to a head with an outbreak of dysentery that ruined the reputation and tourist business of the area for a long time. After that incident, the state board of health was given cooperation. Unfortunately, this case illustrates the unhappy but common occurrence of people failing to remedy a potential danger until something unpleasant actually happens.

Success of the Law

In retrospect, the two most important elements of the Wisconsin law are: [1] the provisions for revocation and suspension of permits, which give the law its teeth; and [2] the regulation of pump installers, for complete control of possible sources of contamination.

Through the years, the number of registered well drillers has remained relatively constant at 400. The number of pump installers is approximately 1,700. It is estimated that there are 300,000 rural wells in Wisconsin. About 8,000–10,000 drilled wells, including new wells and modifications of old wells, are worked on each year.

As evidence of the success of the Wisconsin law and its administration, the percentage of water samples found unsafe by the state laboratory of hygiene has now dropped to 20 per cent, compared to the 70 per cent level of 1935. These figures include all samples submitted from all sources, including tests for new wells and old.

Conclusions and Policy Implications

Some of the insights gained from Wisconsin's experience with the passage and administration of its drinking water law may be helpful to the development of other water regulations and allocation laws.

Students of government have always been plagued by the difficulty of overcoming public apathy and arousing public action before a problem has become so serious that its nature is obvious. If definite information about the number of unsafe well samples had not been available to more or less shock the people into action, it is doubtful that the water law would have been passed in 1935. The situation is similar today. Several humid states, including Wisconsin, are experiencing difficulty with the laws governing allocation of rights to water. As was done prior to the passage of Wisconsin's drinking water law, responsible persons should now be collecting information that will point up the problem to the public, so that a decision can be made before matters become critical. Some of the data needed can be found in well logs required by the well driller regulation. It must be mentioned again that these data should be obtained in a manner that will not arouse well driller opposition, which could frustrate the efforts of states trying to provide safe water supplies.

New regulations to meet new problems are the result of a process that takes place over a period of time. The important provision regulating pump installers, ignored until 1953, and the regulation of well pits came about

gradually. The one best or ideal law cannot be passed once and for all. Any legislation is the culmination of a series of compromises. Critical provisions must be considered first, other items added later. Legislation should not be discussed only as an academic ideal but also as a practical and possible solution to a given problem at a specific time.

Then there is the problem of establishing general rules where widely varying conditions exist. Well construction rules are based on geologic and ground water conditions. It has been suggested that Wisconsin establish water use zones as a basis for regulation. This idea is based on the knowledge that some areas have critical water problems; other areas have plenty of water and either do not need to be regulated or require regulations different from those of critical areas. It is very difficult, however, to draw lines on a map setting up practical zones. Geologists say that they do not yet know enough to set up specific zones based on scientific knowledge. Even when the experts believe that they have enough data to zone an area, and agreements are made on the dividing lines, which happened with Wisconsin forest zoning, the final partition of land may be quite different than was planned. Although zoning decisions may be based on the best technical data available, the final plan depends on what the public wants.

A regulatory body must be adequately staffed and financed if it is to do more than just check on complaints of violations of a statute. The available staff must be large enough to carry on advance planning and to present a program of improvement and development.

Finally, custom and practice are important considerations in the development of formal regulations. An important factor in the passage of the well driller regulation was the cooperation among well drillers within their association, and an awareness that the regulation protected the capable driller against the irresponsible practices of drillers who did substandard work that gave the entire industry a bad reputation. As conflicts among ground water users increase, information should be gathered on how these conflicts are now being resolved, though no formal procedures and laws may be available yet in many states.

Acknowledgment

The author acknowledges the helpful information supplied by Harvey Wirth, of the Wisconsin State Board of Health; Guy Peterson, well driller, Madison, Wis.; and Ernest Bean, former Wisconsin State Geologist.

Water Resources Program in Ontario

Albert E. Berry

A paper presented on Sep. 9, 1959, at the Canadian Section Meeting, Maritime Branch, Liverpool, N.S., by Albert E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Com., Toronto, Ont.

THE program of the Ontario Water Resources Commission (OWRC) is now well advanced. Of particular interest is the legislation that gave rise to a new kind of administration, the work involved in enabling this administration to operate, and the steps that have been taken to date.

Programs pertaining to water resources were put under the control of a commission by an act passed in 1956. Such an act was unique in Canada, and elsewhere, insofar as the contents of the legislation were concerned. It is interesting that similar legislation has since been passed in the province of New Brunswick. The legislation in Ontario had as its objective an adequate supply of water to all communities, under the most favorable conditions of finance and administration. The construction of sewage facilities to protect the water resources of the province was made a part of the program. This move recognizes principles that are of the utmost importance in the development and orderly progress of any country.

Need for Program

A program like Ontario's is undertaken because conditions require it. Events preceding the 1956 act clearly pointed to the urgent water supply requirements in parts of the province where a growth in population was expected. It was also clearly shown that water resources must be guarded against the ravages of pollution. A better understanding of the need for a new program may be had from an analysis of the factors, which developed over a period of time.

Ontario has a population of more than 5,500,000. It covers an area of 412,582 sq mi, compared to a total of 3,845,794 sq mi for all of Canada. The scattered distribution of population creates problems where community projects are involved. Southern Ontario has the highest concentration of population and has been a focal point for industrial growth. Opportunities for continued growth are great, but the problems associated with it are also great.

It is recognized that for any area, growth and human betterment cannot be sustained unless there are adequate water supplies available. These supplies are a great national asset, and their quality must be protected at all costs. The importance of the Great Lakes system to southern Ontario is clearly evident. Large communities and industries have developed near these waters for many years. Now, as communities and industries move inland, the adequacy of water supplies and the prevention of pollution take on a new significance.

Many inland communities in southern Ontario are confronted by water supply problems. Rapid runoff and

the resulting decrease in stream flows during the summer months make pollution a serious problem. Costs of water development and transportation have risen sharply, and high interest rates have added to the financial burden. It is even more essential to protect local water supplies from pollution when the cost of obtaining water from remote sources is so great. When water must be piped long distances, or when the most economical arrangement is necessary for sewage and waste disposal, there is an advantage in dealing with these on a regional basis for a number of municipalities, rather than having each municipality attempt to solve its own problems. Individual efforts in the past have not led to the most effective solutions to these problems.

Government Action

The adverse conditions that might affect Ontario's water resources were foreseen by the government of the province, and a water resources and supply committee was appointed in 1955 to inquire into and to advise on a constructive program. The committee consisted of five members, who made a report that same year. Legislation, made effective in April 1956, led to the appointment of a water resources commission consisting of five members. This first legislative enactment authorized the development of an organization and the necessary procedures for carrying out the program. The bill was considerably altered in April 1957 and was named the Ontario Water Resources Commission Act, 1957. Other amendments were made in 1958. With this legislation, the commission was able to proceed aggressively to gain its objectives.

OWRC Act

The broad scope of authority given to OWRC is specified in Section 16 of the Ontario Water Resources Commission Act, which reads as follows:

> Notwithstanding any other Act, it is the function of the Commission and it has power,
>
> a. To control and regulate the collection, production, treatment, storage, transmission, distribution, and use of water for public purposes and to make orders with respect thereto
>
> b. To construct, acquire, provide, operate, and maintain water works and to develop and make available supplies of water to municipalities and persons
>
> c. To construct, acquire, provide, operate, and maintain sewage works and to receive, treat, and dispose of sewage delivered by municipalities and persons
>
> d. To make agreements with any one or more municipalities or persons with respect to a supply of water or the reception, treatment, and disposal of sewage
>
> e. To conduct research programs and to prepare statistics for its purposes
>
> f. To perform such other functions or discharge such other duties as may be assigned to it from time to time by the Lieutenant-Governor in Council.

The major features of this legislation may be considered in two parts: one dealing with the supervision by the commission of all water and sewage works in the province, the other having to do with the construction of water and sewage projects by the commission for municipalities and other bodies.

OWRC Supervision

For many years the Ontario Department of Health was authorized by public health legislation to supervise water and sewage facilities built and maintained by municipalities or individuals. This was similar to what was

done in other provinces of Canada and in most of the United States. Under the Water Resources Commission Act, legislation contained in the Public Health Act not only was transferred to the commission but also was considerably expanded and altered to permit more effective control. This was especially so with regard to stream pollution.

This new program for the construction of water and sewage facilities is a distinct departure from the procedures of the past. Furthermore, it is believed to be different from practices followed in other countries. The object is to help municipalities meet their demands for these facilities. The commission offers financial aid as well as expert technical assistance in the planning, construction, and operation of the facilities. This procedure obviates a municipality's need to issue bonds or to borrow money for water supply and sewage disposal projects.

Construction Procedures

The procedure followed by the commission in its construction program has several new features not otherwise utilized in Ontario. In the first place, any municipality is free to decide whether it wishes to do its own work or have the commission do it. The services of the commission are available to any municipality, but no effort is made to urge that a project be turned over to OWRC. The chief desire of the commission is to see that the work progresses. If the municipality so requests, an agreement can be made between it and the commission, under which the latter undertakes to design, build, finance, and operate the water or sewage project. A standard form of agreement is used, subject to minor alterations depending on local conditions. This agreement on a project may involve one or several municipalities, as well as industries. It may concern very small utilities or very large ones. Particular emphasis is placed on joint projects that will serve a number of municipalities, whether these projects be for water supply or sewage disposal.

Projects undertaken by the commission are, in general, confined to those for the supply, treatment, and delivery of water through feeder mains to the contracting party's distribution system, or to trunk sewers, treatment plants, and sewer outfalls. Only for small communities does the commission undertake to construct local water distribution mains or a sewage collection system. In these instances, there is a definite advantage in having all the work done under one contract and under one management.

When the agreement has been approved by both parties, the commission proceeds with the necessary plans and specifications. The policy of the commission has been to appoint consulting engineers to do the design work and the field supervision during construction. Thus, the consulting engineer is an employee of the commission rather than of the municipality. He engages the resident engineers and field staff to supervise construction. The commission, on its own, maintains a construction branch to deal with this work and to insure that the project is carried out to its satisfaction.

All contracts for these projects are awarded by the commission, and the complete program is under its direct supervision. Payments are made to the contractor as the work progresses, to the suppliers of equipment, and to the consulting engineers. In this way,

no payments are made by the contracting municipality until the facilities are in operation.

The agreement beween a municipality and the commission is based on the latter's assuming the responsibility for the operation and maintenance of the utility during the lifetime of the debt. When the project is constructed, this responsibility passes from the commission's construction division to its operating division. The personnel for the operations are engaged by and paid by the commission. If a small utility is involved, which does not require the services of a full-time staff, arrangements may be made to employ on a part-time basis some of the employees of the municipality.

The agreement between the municipality and the commission contains a clause whereby at the termination of the debt, the utility may be returned to the municipality at the request of either party. Extensions or enlargements of the project may be made by the commission at the request of the municipality; in this way, the debt retirement period may be extended for a longer period. Each of these extensions involves a new agreement between the commission and the municipality. The commission does not have the right to extend the original project under the terms of the first agreement.

An important part of this entire program is the means for cooperation between the commission and the municipalities served. Each municipality is asked to appoint a local advisory committee to work with the commission and to deal with all aspects of the program. In this way, there is a local direction for such matters as appointment of employees, wages paid, and many other features of administration. Thus, the activity is related to local conditions rather than to one set of standards or requirements for the entire province.

The commission offers to each municipality extensive services for the operation of utilities. In technical matters, the activity of the local engineering staff is coordinated with the specialized activities of the commission's personnel. In small municipalities, where new utilities are being installed and where there has been little experience with such projects, the commission advises on all aspects of administration, including rate structures, bookkeeping, and records. In this way, at no cost, each municipality is granted full use of the commission's laboratory facilities and its technical staff.

Financial Arrangements

The financial arrangements for the projects constructed and operated by the commission are an important part of the overall program. Stringent money conditions, such as high interest rates, and the difficulty of obtaining loans have added to the burdens of municipalities in financing undertakings on their own. With the plan offered by the commission, the municipality does not issue or sell any debentures or bonds. Money is advanced by the commission; the credit of the province backs up the debt. The debt is paid back over a long period, 30 years in most instances, but this may be varied according to the wishes of the municipality. The interest rate is the actual cost of money borrowed by the province. This rate is usually lower than it would be if the municipality borrowed money on the open market. The indebtedness of the commission can be met by the sale of its

own bonds, which are guaranteed by the province. The commission can also borrow directly, as it has to date, from the provincial treasurer, thereby benefiting from the savings that come from large-scale borrowing.

This method of financing has a number of advantages in addition to the more favorable interest rate. One is the flexility of the agreement. The municipality makes no payment to the commission until the utility is put into operation. The debenture period may be adjusted to suit the municipality. Principal payments may be deferred at the outset and for as long as 5 years after the work is completed. The interest rate will vary each year, and as the prevailing interest rate is lowered, the municipality benefits from further savings.

In Ontario, all financial obligations to be incurred by municipalities come under the supervision of the Ontario Municipal Board. The board thus determines whether the municipality is capable of paying back the money it wants to borrow. This same requirement applies whether the municipality is doing the work on its own or turning the project over to OWRC. In the latter instance, the commission deals directly with the board for the municipality.

When a number of municipalities are involved with a single project, the financial agreement provides for the allocation to each municipality of that part of the capital debt for which it will be responsible to the commission. The cost of the water delivered or the sewage treated is based on the capital debt and the actual cost of operation. At present, the commission is undertaking sewage projects in which a number of municipalities will be provided with joint services, including trunk sewers as well as treatment facilities.

The basis of all financial agreements with municipalities is that they shall pay to the commission the actual costs of the debt and services rendered. The latter does not include the cost of the commission's supervisory services, only the cost of those operators actually working on the project. No money grants are involved in these programs. The contracting municipality will pay quarterly to the commission an estimated amount of the capital debt and operating charges, as well as a reserve fund for contingencies, repairs, and replacements. At the end of the year, after the actual costs are totaled, an adjustment is made with the municipality. These financial procedures relieve the municipality of all details involved in borrowing money for capital works.

Supervision of Sewage Facilities

Another aspect of the commission's program deals with the supervision of sanitation in sewage plants and water utilities. This supervisory activity is similar to that normally carried out by a provincial health department. All plans for the installation of water and sewage facilities, or the extension of existing facilities, require the approval of the commission before construction begins. In this way, the commission has broad powers to deal with the water resources of the province and the right to regulate water use.

Great emphasis is placed on the control of stream pollution. If water resources are to be made available for maximum use and public benefit, pollution control must be enforced rigidly. The commission, by law, is empowered to protect all water supplies. Heavy

penalties are provided for the infringement of pollution regulations. A departure from the usual public health provision against pollution is that, under the commission's program, pollution control is not confined only to those conditions affecting public health, but also to any condition that may impair the quality of a receiving watercourse. Since the inception of the commission, a good deal of its activity has been devoted to sewage and waste disposal and to the abatement of stream pollution.

Results of Program

The program of the commission is still in its early stages; the OWRC Act came into effect only in April 1957. It is gratifying to note the number of projects that have been undertaken since that time. To date, agreements have been made with municipalities for 83 projects, involving an estimated expenditure of approximately $40,000,000. These include 40 water supply projects and 43 sewage facilities. Twenty-four of these are already in operation; others are in various stages of development. In many other instances, agreements are pending, and the preliminary engineering work is now being done. Water will be pumped for considerable distances, and sources of water supply, both surface and underground, will be developed wherever they are considered most advantageous. Sewage treatment will be provided to suit local needs, and trunk sewers will be constructed to treatment plant sites or to outlets. Sewage treatment and pollution control will be regarded not as functions limited to each municipality, but as the concern of an entire area. Therefore, regardless of the area in which a municipality is located, its sewage treatment facilities may operate in conjunction with those in adjacent areas. Such projects will result in efficient and economical operations for all concerned.

Summary

A review of the program of OWRC emphasizes the significance of its objective to facilitate the development of water supplies and sewage disposal plants for all municipalities, whether they be situated inland or near large bodies of water. The province has adopted a program for the development and conservation of water resources and for pollution abatement, with full protection of all watercourses in the province. This program pertains to municipalities and industries. A great deal of effort is being devoted to making surveys of all water sources and for determining the discharges to watercourses. Special efforts are being made for the control of drainage outfalls in municipalities. In this way, it is hoped that all streams will be cleared of pollution. This is a further step in a program aimed at close cooperation between the province and its municipalities. The results obtained to date have been most gratifying, in spite of the large expenditures required for these works. It is not possible to predict accurately the length of time needed to deal with these major programs and, especially, to eliminate all stream pollution. The work, however, is proceeding rapidly. Municipalities and industry have cooperated splendidly with the commission.

Modern methods of water purification are being employed in commission programs. The degree of treatment of sewage and industrial wastes depends on how much protection is required to preserve the quality of a water-

course. Naturally, this will vary with local conditions. The trend, however, is definitely toward more complete treatment and for raising the standard of stream sanitation throughout the province. As the treatment plants come into operation, rigid control will be exercised by the commission to prevent the discharge of untreated or inadequately treated wastes that might pollute water supplies. In this way, it is believed that water problems resulting from expanding populations and industries can be held to a minimum. At the same time, streams can be utilized for the disposal of effluents without undue impairment of water quality. With the cooperation of those participating, the province cannot fail to achieve its objectives.

Revision of Steel Pipe Standards (AWWA C201, C202)

On Jul. 17, 1959, the AWWA Board of Directors approved several changes in AWWA C201–50—Standard for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over, and in AWWA C202–49—Standard for Steel Water Pipe of Sizes up to But Not Including 30 Inches. The revised standards have been redesignated, respectively, "AWWA C201–59" and "AWWA C202–59." The revised sections will read as follows:

AWWA C201

3–2.1.1. Steel plates shall conform to ASTM A283, Grades B, C, or D, of latest revision, or to other grades of steel having strength and weldability of proved equality; all as specified by the purchaser.

3–3.12.8. *Plain Ends Fitted With Flanges:* Ends to be fitted with flanges shall have the longitudinal or spiral weld beads on the pipe ground to plate surface for a distance 1 in. greater than the hub depth of the flange to be attached. Flanges shall be of the type specified in AWWA C207 and shall be welded to the pipe as specified and shown therein, or as otherwise specified by the purchaser.

AWWA C202

4–1.2.7 [regarding supplementary details to be provided by purchaser]: The maximum number of longitudinal and girth seams permitted in each fabricated pipe section or the maximum number of lengths of mill pipe which are to be jointed in accordance with Sec. A4-2 in the Appendix to this standard.

4–2.2.2. Steel plates for fabricated pipe shall conform to the chemical requirements of ASTM A283, Grades B, C, or D, of latest revision, or to those of other grades of steel having strength and weldability of proved equality; all as specified by the purchaser.

4–2.4.2. Steel plates for fabricated pipe shall conform to the physical properties of ASTM A283, Grades B, C, or D, of latest revision, or to those of other grades of steel having strength and weldability of proved equality; all as specified by the purchaser.

4–3.9.8. *Plain Ends Fitted With Flanges:* Ends to be fitted with flanges shall have the longitudinal or spiral weld beads on the pipe ground to plate surface for a distance 1 in. greater than the hub depth of the flange to be attached. Flanges shall be of the type specified in AWWA C207 and shall be welded to the pipe as specified and shown therein, or as otherwise specified by the purchaser.

Need for Demand Meters

Panel Discussion

A panel discussion presented on Jul. 16, 1959, at the Annual Conference, San Francisco, Calif.

George H. Dann

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OWING to the heavy loads placed on most water systems by increasing demands in the last 10–15 years, millions of dollars have been spent on construction, improvement of operations, training of personnel, and public relations. It is felt that a fair share of the cost of improved service has not been charged against those customers who have, for the most part, made the expenditures necessary. The water supply agency must be equipped to meet the peak loads placed upon its facilities at any moment; in addition, it must meet any unusual demand problem peculiar to its system. Those customers who are largely responsible for peak loads should be billed partly according to the extent to which the utility must be ready to serve them.

The Problem

Many water utilities serve a number of golf courses; the author's utility, for example, serves 26. To supply these golf courses with the water they may demand during their peak use period, a certain supply, treatment, pumping, transmission, and distribution capacity must be provided. During dry periods, the demand for golf course sprinkling increases. The demands placed upon the system by these customers have been fantastic as compared to the normal summer peak demands. After a rainy period the same customers use little or no water, but facilities must nevertheless be provided to serve them if and when their needs increase.

Most water utilities serving primarily domestic customers experience peak loads during the early evening lawn-sprinkling hours. This poses the question of whether a demand charge should be imposed on those domestic accounts. This, of course, is a problem that must be resolved by each water utility after a study of the peak demands and the rate schedule. In the majority of instances it is doubtful that the installation of demand instruments on normal domestic services would be economically feasible. Consumers with swimming pools, nonrecirculating air-conditioning units, and automatic lawn sprinklers should be distinguished from the average domestic consumer and be required to pay for service on a different basis.

Some time ago a real estate developer made application to the author's firm for water to supply 95 homes in a remote section. Each home was to have a swimming pool of 30,000-gal capacity. It is not unlikely that each of the pool owners would choose the same sunny spring day to fill his pool. It is estimated that to fill the 95 swimming pools in a 24-hr period, 1,975 gpm, or 2.85 mgd, would be required. Such a demand would require a 16-in.

supply main, which would cost \$425,000; whereas the largest main in the general area is only 8 in. in diameter. Mere extensions of the normal distribution mains would give adequate service for normal customers. It is true that the peak for the swimming pool demand could be met with ground level storage at a cost of approximately \$100,000. If the swimming-pool demand were coupled with abnormal sprinkling demands, however, the storage facilities could not be replenished. Although demand-metering equipment is not advocated for average domestic customers, the swimming-pool example is certainly not average, even though the modern trend is in that direction.

Many other facilities, such as large air-conditioned buildings and certain industrial and commercial plants, use large quantities of water. Unfortunately these customers are not always new accounts in outlying districts; existing customers who have been supplied through an adequate distribution system may make certain changes that increase their water requirements and adversely affect the distribution system. These facilities normally impose high loads just at the time the system load is at its peak. This is especially true in areas where a great percentage of the water produced is consumed by industrial and commercial plants. Even though high demands may not occur simultaneously with the peak loads in residential areas, they do tend to increase the time factor and prolong the system peak loads. A customer who imposes heavy demands does not pay his fair share of the cost of providing water during the critical periods.

Need for Demand Meters

There should be some means whereby heavy demands on the system could be measured and a fair and equitable charge could be made—a charge that should be paid to offset large capital investments and high operating costs. The only equitable method of allocating this cost is to determine the instantaneous demand imposed by each customer. Quarterly or monthly meter readings may show high consumption during various periods or certain seasons of the year, and those who impose such abnormal loads should pay the expense of the additional facilities required for the service. Other customers may impose extreme loads that cannot be determined by monthly or quarterly readings. The customer who uses large volumes of water at certain hours of the day or certain days of the week should also pay his proper share. Although his overall consumption may not be excessive, instantaneous demand is a very important factor. The cost allocation should be a function of both the instantaneous demand and the total use in each billing period, and the demand meter provides a logical means of measuring this demand.

Other types of utilities have been faced with the problem of excessive loads; the electric industry solved it with demand metering years ago. Why then, with the advanced techniques that the water industry uses in other phases of its operation, does it still adhere to long outdated metering and billing methods?

The responsibility of solving the problem rests with the water utility manager. He must tell the equipment manufacturer just what tools are required and develop specifications for their manufacture. In addition, rate scheduling must be developed so that demand metering equipment may be effectively utilized to indicate the influence of the demand of each customer on the system loads.

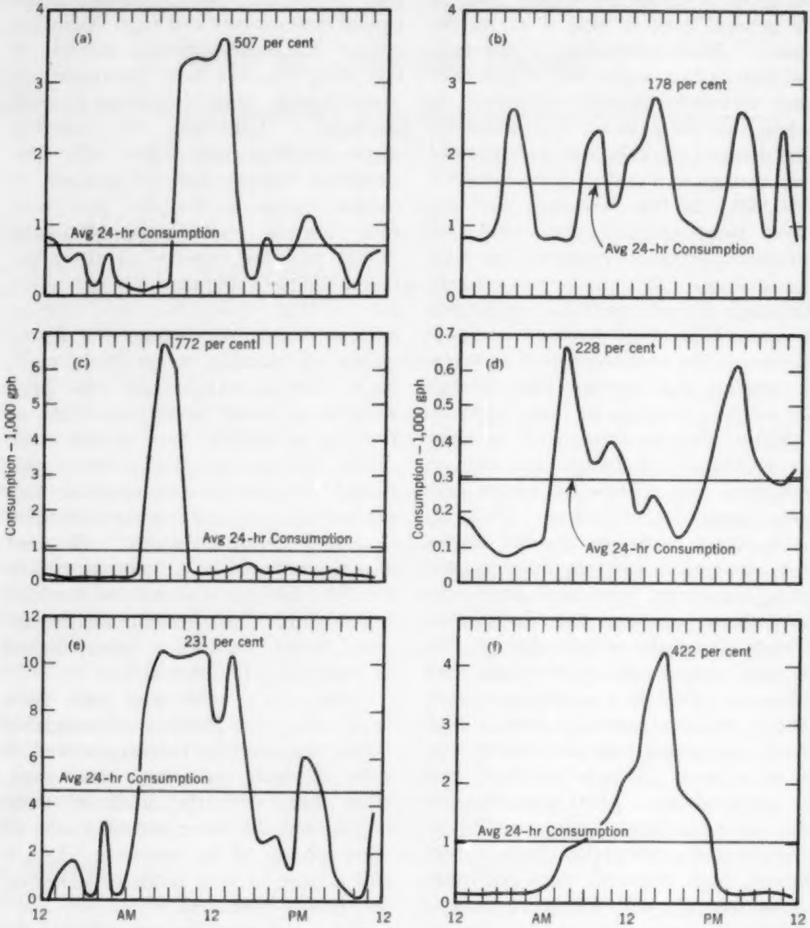

Fig. 1. Hourly Variation in Demand Rates for Several Service Types

Parts a *and* b *show the demand variations for two industries; Part* c, *a golf course; Part* d, *an apartment; Part* e, *a school; and Part* f, *a hospital. The curves are based on actual field test data and no one curve is intended to be typical of all members of a service type. They do, however, give an indication of the wide variation in demands imposed by various customer classes. The diversity is great within each class, although a definite pattern is evident.*

Before a demand-metering program is initiated, the public must be educated to understand the problems caused by peak loads. Every effort must be made by the industry to aid the customer in decreasing his use during peak hours, so that he does not pay for any unnecessary instantaneous use. This may be accomplished by investigating each customer's requirements to determine the most suitable and economical size of service supply and what measures may be taken to install devices for water conservation or for distributing his demand more evenly. Such a program would show the customer that the utility does not wish to impose any unreasonable burden upon him—that it is making every effort to insure the customer that he will be paying only his fair share of the burden.

In addition to the effect of excessive demands on the water supply system, there is another important factor to consider. With the inception of demand meters, peak loads would be likely to decrease as the consumers realize the economy of distributing their water use over a longer period of time, thus reducing instantaneous demand. This, in turn, would result in the more efficient utilization of existing facilities, and possibly defer future expansion and result in an overall saving both to the customer and to the utility.

Field Test Data

To show the peak demands imposed by various classes of consumers, the author's utility made a number of field tests during the winter and spring months. Recording charts were installed on the meters of various customers on the system. As the investigations were made in the winter and spring months, the consumption figures do not include the extra water for air-conditioning and abnormal seasonal demands that would be added to the picture during the summer months. Therefore, the data give a conservative picture of the problem. From the field data a few graphs have been drawn to show the daily peak demands of various types of commercial and industrial consumers. In these graphs (Fig. 1) the average daily consumption is shown as well as the variation in demand with respect to time.

The water supply industry is being forced to face the same problem that caused the electric industry to adopt the demand meter as a means of equitably distributing the cost of supplying their customers during periods of peak loads. This problem has existed for a long time, and it may be asked why there is so much interest in it at this particular time. The Philadelphia Suburban Water Co. is interested because its territory, which is adjacent to a large city in a metropolitan area, gives signs that it is ripe for transition from an area largely consisting of domestic customers to an area where a much greater portion of the production will be required for commercial and industrial use. It is felt that the time to plan for this new situation is now, rather than after the problem has actually arrived.

Acknowledgment

The author wishes to express his appreciation to Elmer J. Pollock of Philadelphia Suburban Water Co., for his able assistance in compiling the data used in this article.

Melvin P. Hatcher

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The water supply industry is just beginning to realize the need for attention to the load factor effects of the various classes of service. For years the industry was able to depend upon a rather constant ratio between maximum day and average day and with a rather standard form of rate designed to account for the load factor in a fairly reasonable way. About 10 years ago the use of air-conditioning equipment began to grow by leaps and bounds. This new water use began to impose very serious loads on public water supply systems, particularly in the midwest. The maximum day for periods of air-conditioning use is seven to eight times the average day, whereas, for the regular run of industrial and commercial service, the maximum day is about 1½ times the average day. Air-conditioning use is an expensive class of service and there is no way of recouping the extra cost under a traditional rate plan. On the other hand, a demand, or two-part, rate would insure adequate returns for this service.

Present Applications

Kansas City, Mo., has another reason for using a demand or two-part type of rate. Before recent annexations, 15 per cent of Kansas City's maximum daily demand was accounted for by fifteen public water supply agencies purchasing water at or near the city limits for use in adjoining suburban areas. For 11 years it has made use of a demand-commodity rate that has also included a factor for a distance from the central pumping station. This demand-distance rate, which has been described in the JOURNAL (*1*), has served quite well.

Several years ago Milwaukee made its first effort toward a demand rate for suburban service. That first effort was rejected by the Wisconsin Public Service Commission. More recently the commission has approved a two-part rate for suburban service in Milwaukee and the rate is mandatory for five purchasers of water for use outside of Milwaukee. The Milwaukee rate is based on the maximum hourly demand, whereas the Kansas City sub-

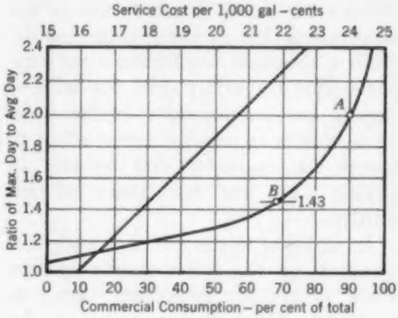

Fig. 2. Load Factor for and Cost of Commercial Service

The load factor curve is so drawn that, at Point A, *for example, 90 per cent of the total consumption has a maximum day–average day ratio of 2.0 or less. Point* B *is the average maximum day–average day ratio for all commercial services. The straight-line graph shows the cost of providing service at various demand ratios.*

urban demand rate is based on the maximum day.

In small systems there appears to be need for demand metering when some major industry uses as much as half of the system capacity. Demand metering would provide an adequate measure of the cost of service to such an industry.

It has been the author's feeling that whether or not a two-part rate is justified for regular commercial and indus-

trial service depends somewhat on the trend in rates for this class of service. Studies of the cost of water service for air conditioning have indicated that the most equitable type of rate includes a demand charge based on air-conditioning capacity plus a charge for total consumption. A number of such rate schedules have been initiated. A charge of $40 per ton per year, tentatively allowed to the St. Louis County Water Co., has since been rejected by the Missouri Public Service Commission. A $7.50 charge at Detroit and the $36 charge in Omaha are being questioned in the courts and it is not known what the outcome will be. If charges of this kind are disallowed by the courts on the ground that they are discriminatory, it may be necessary for the water supply industry to adopt a two-part rate for the greater part of commercial and industrial consumption. Application of such a rate to all service may prove impractical. The rate may well have to be made to apply to all meters above a certain size or on all classes of service with a certain maximum daily demand or greater.

As of the present time, the author knows of only two instances of the use of such rates; in both instances the use has been optional. Milwaukee has recently adopted two-part rates for individual consumers inside and outside the city limits. The rates for service inside the city are a little lower than those outside. St. Louis has a two-part rate which came about because of the insistence of a large chemical concern that had a very favorable yearly load factor.

Optional demand rates do not appear to be a proper solution. Their effect is bound to be that consumers with favorable load factors will choose the demand rate and thus make necessary higher commodity costs for other commercial and industrial services. Again it appears that the only workable method of demand metering is to include all commercial and industrial customers using meters above a certain size or having demands that exceed a certain level.

Kansas City Load Problems

Several years ago the author made a survey of yearly load factor for customers accounting for 30 per cent of the yearly commercial and industrial consumption in Kansas City. The results of that survey are shown in Fig. 2. The maximum day was 1.43 times the average day and this ratio ranged from 1.04 to 2.40 for 95 per cent of the total consumption. It should be noted further that water supplied at the 2.40 ratio cost 40 per cent more than water supplied at the lowest ratio. This range suggests the need for a better distribution of costs; demand metering is likely to come, as it did in St. Louis, when customers with favorable load factors understand the extent to which they are subsidizing customers with poor load factors.

To determine demand, Kansas City uses a recording instrument attached to regular displacement meters. The charge for service is based on the maximum day in the summer months with an extra charge for hourly use in the period from 4:30 PM to 8:30 PM. Charts are changed daily. There is a need for metering equipment that can provide for combinations of meter readings and require less frequent chart changes.

Reference

1. Hatcher, M. P. Distance and Demand Factors in Suburban Water Rates. *Jour. AWWA,* **42**:1003 (Nov. 1950).

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A demand-metering program is bound to be unpopular at first among many customers, particularly those whose seasonal water demands are fairly pronounced, as demand metering would cause them higher billing charges. The primary motive behind the installation of demand meters probably is not to afford lower bills to customers whose load factors are better than average, but to collect a more correct charge for service to customers who impose relatively high demands in spite of small volumetric water use. The customer whose demand is inordinately high naturally cannot be expected to be in favor of a change from a metering system that places the burden of the cost of serving him on other customers. His position is not entirely inexcusable, either, for many men in the water supply industry, itself, question the need and practicability of demand metering. This latter point of view is further strengthened (particularly in the past) by the lack of equipment that would make demand metering as practical and economical as conventional methods.

Basis for Demand Rates

Owing to limitations of space, only a few phases of the problem of demand metering may here be explored. Although there are many differing points of view on the subject of demand metering, the buyer, seller, manufacturer, engineer, and economist can all agree on certain fundamental concepts that stem from the economics of supplying water. Some of these are:

1. The factors that determine the cost of supplying water service may be conveniently divided into three broad categories: demand rate, volume delivered, and customer type (location and number).
2. A water system must be so designed and operated as to be capable of continually supplying the quantity of water required at the demand rate, even during peak periods.
3. The total revenue received for water service in the overall system must not be less than the cost of providing the service for the entire system.
4. Water use characteristics may vary greatly between different classes of customers and between customers within a class. Such variation is not only in the volume delivered but also, more importantly, in the relationship between the average demand rate and maximum demand rate.
5. The ratio of the peak demand imposed by a customer to his average demand is one of the important factors that determine the cost of service. Generally speaking, a low load factor results in higher unit costs than a high load factor.
6. The blocked, volumetric rate schedule, as normally used, is capable of only partly assessing those variations in the cost of service that are due to differing customer demand characteristics—and then sometimes only very inadequately.
7. It is in the general interest of both the seller and the customer to improve the water consumption pattern of the system and reduce discrimination and preference in billing different classes of customers and different customers within a given class.

Need for a Change

Depending upon one's point of view, it may be either a hindrance or a blessing that the water industry has not had to compete with an alternative industry, as have the electric and gas industries.

Demand metering has been used in the electric industry for many reasons, including the adaptability of the product to a constantly increasing multiplicity of uses and the necessity to meet competitive price conditions. Through the use of demand metering, a rate schedule can be made to correspond with the pattern of costs of service or to meet a competitive cost pattern.

In the water industry, the time is rapidly coming when both the utility's and the customer's interests will require more adequate means of metering and billing for water service. It will be necessary that charges be more properly assessed in order to cope with the constantly increasing capital cost of providing water supplies for the needs of a growing population and a rising standard of living and to encourage a more judicious use of system facilities. An increase in volumetric use for a given demand means lower system costs and permits lower charges for water service.

Field of Application

The field of application for demand metering is fairly clear—that is, large water services such as for resale, wholesale, or redistribution, and for large industrial, municipal, or special water uses. Included in this category are customers who have supplemental water supplies. Many smaller water systems may have few, if any, such services, and, therefore, it might be urged that demand metering is of no practical concern to them. There is a phase of demand metering that can be applied to all systems, however; check metering of selected service installations can help any utility better to understand the demand characteristics of its system. Such checks not only supply useful information about day-to-day operations and system design, but they also provide information that permits a more intelligent approach to rate structure design, and they are therefore of real benefit both to the customer and to the utility.

Substantial benefits are possible through the application of demand rate structures where they can be applied advantageously through use of ordinary volumetric meter readings. By utilizing the consumption in the maximum month during the last period of 11 months as the monthly demand constant and the recorded monthly volumetric consumption, seasonal variations in customer demands may be readily assessed and appropriate rate structures may be established. Such a method should be more acceptable to the customer, as the sharp peak demands within the month would be depressed. An examination of a year's consumption by months generally shows that such a basis for charge is reasonably effective as a step toward demand metering. If the seasonal variations are minor, there may be little need for demand metering.

Demand Period

In demand metering, 24-hr demand period is generally viewed as a sufficiently short unit, although the hourly demand is commonly used in the electrical industry. Electric power cannot be stored, and when a customer imposes a kilowatt of demand at the place of use, that power must be instantaneously available from generation and transmitted to the customer. In the gas industry, the 24-hr period is generally used as the unit for demand calculations. Gas may be stored to meet hourly fluctuations in demand within the distribution service area. This is also usually true in a water system, where local storage is provided to an even greater extent.

In the author's opinion, if demand calculations are made on the maximum deliveries over a 24-hr period, the demand rate can usually be adequately assessed. It must be remembered that several customers who periodically impose high demands as compared to their average demands may collectively afford a diversity in the system load for other customers to utilize, because they do not impose the demands simultaneously. From the viewpoint of the buyer, demand rates based on a 24-hr period would be more acceptable than rates based on a shorter period. Greater equity would also result between customers, especially if the simultaneous-demand theory is used to spread the costs between customer groups rather than a nonsimultaneous-demand basis.

Summary

Demand metering may initially gain rather limited customer acceptance. The industry must, itself, better understand, and believe in, advantages of demand metering. When demand metering and billing are realistically applie for classes of service to which it is adaptable, it has a real place in the water industry and not only makes more equitable billings, but also assists in developing better water use characteristics and hence lower operation costs.

The water industry should view demand metering as a tool, which, when properly put to use, can provide a better means to apportion costs and revenue requirements between different customer groups. This can be done in two ways: [1] through actual demand metering, where justified, of certain classes of customers, and [2] by making demand checks of the large group of customers for whom demand metering is not practical, in order to secure sample data that will enable the utility to plan and operate more intelligently as well as to improve its rate structure.

W. Victor Weir

President, St. Louis County Water Co., St. Louis, Mo. (deceased).

In discussions of the need for demand registering water meters it must be recognized that equipment that will provide data for demand billing is already available, if any utility wishes to use it. This equipment, which is available from several manufacturers, usually consists of a graphic recorder connected mechanically to a selected hand on the meter dial. The water use data can be recorded on a daily or a weekly chart and can be interpreted to give the actual demand for any selected period. Equipment of this sort has been used for a number of years by the Kansas City (Mo.) Water Department, to allow it to bill a limited number of customers on a demand basis. It is used by many other utilities to obtain information concerning customer use of water.

Present Practices

Some water utilities are presently following demand billing practices. In addition to the Kansas City practice, which covers water sales to outside water utilities, undoubtedly many instances of demand billing can be cited.

Demand charges are made on nonconserving water cooled air-conditioning equipment in a number of cities. Air-conditioning equipment has a fairly consistent requirement of water per ton of capacity in any specific locality, and it has a reasonably consistent pattern of use. By correlating capacity and use, a load factor can be developed and an equitable demand charge can

be established, based upon the capacity of the air-conditioning equipment. The highest charge with which the author is familiar is an annual charge of $45 per ton levied at Champaign, Ill.

The St. Louis County Water Co. also has a demand-billing rate that is applicable to large commercial, industrial, and institutional users. At the present time there are 58 of 147,000 customers under this rate program. The charge is $120 for the first 60,000 cu ft (approximately 448,700 gal) or less per month and $0.13 per 100 cu ft in excess of 60,000 cu ft per month. The minimum charge per month is 60 per cent of the maximum charge during any of the months during June–September in the 12-month period preceding the month for which the bill is rendered, but not less than $120.

In 1958 demand-billed customers provided $465,000 of revenue. Minimum bills based upon the 60 per cent ratchet feature were issued in many instances and brought in $38,000 of additional revenue from the customers with lower load factors.

Another type of demand billing is the practice of making charges for fire protection service. Charges are based upon the cost of readiness to serve—adjusted by various subjective (or even political) considerations which usually reduce the charges, sometimes to zero. There is great nonuniformity in the practices of utilities in making these charges. One privately owned utility gets about 2.5 per cent of its revenue from private and public fire protection, whereas another gets 4.9 per cent. One municipally owned utility gets 0.2 per cent from private fire protection and nothing from public fire protection; another gets 5.5 per cent from both sources.

Another type of demand billing is the application of service or minimum charges to the customers. These charges generally increase as the size of the water meter increases. It is fair to say that such demand charges cover too small a portion of the actual demand costs to utilities, particularly for larger meters.

Value of Demand Rates

Many have said that the water industry should follow the electric industry in adopting demand metering, arguing that the electric industry, by utilizing this method, has established a nondiscriminatory basis for billing. It has been generally assumed that the demand-billing practices of the electric industry are scientific and accurate, but this may not be absolutely true.

The electric industry has widely adopted demand rates originated by John Hopkinson of England in 1892 and by Arthur Wright, also of England, in 1896. Some variations have been made, such as combining the two methods, but the electric industry has not deviated far from the principles laid down almost 60 years ago. L. R. Nash, in his book, *Public Utility Rate Structures,* stated:

> A basic purpose of this book is to portray rate making not as an exact, scientific procedure but as a skillful balancing of conflicting objectives, a curbing of tendencies toward technical complications, and an avoidance of undue yielding to the public urge for the simplicity prevailing in other commercial transactions. The results of such balancing will differ with the character of the service and the number of customers involved. The successful builder of rate structures must be *primarily a philosopher* rather than a technician. [Emphasis supplied.]

G. C. Delvaille, in an article (*1*), said:

> In actual practice, the main problem that confronts the rate engineer is to

obtain the total amount of money necessary to operate the utility at a reasonable profit with the least complaints from any one class of customers . . . in the final analysis, rate making in actual practice is a matter of weighing all forces exerting an influence on rates and [of] exercising sound judgment.

Russell E. Caywood, in his book, *Electric Utility Rate Economics* (2), has this to say about the philosophy of establishing electric utility rates:

> Rates cannot be set above the value of service to the customer, if the utility expects to get . . . [its] . . . business; this is the upper price limit. Neither should rates be set below the incremental cost; this is the lower price limit. Within this price zone, *the utility must use its judgment* as to the price most satisfactory to customers and utility alike.

In developing demand rates, the electric industry, of course, makes various allocations of cost. There are five well known methods of allocating demand and seven additional methods of allocating both demand and consumption. These twelve accepted methods result in twelve different answers and necessarily cover a wide range of possibilities. Caywood further said:

> Individual rates are a working compromise between theory and practice. Numerous items influence pricing in any business, whether regulated or not. Costs are nothing more than an allocation or distribution of investment and expenses: they are not necessarily a measure of reasonable rates, but can serve as a guide to judgments in the rate-making process.

It should be apparent that demand rate practices in the electric industry are not necessarily much more accurate than the present rate practices in the water industry.

Another indication that the electric industry's rates are not as exact as some might believe is the rate book of any large electric utility. Instead of containing a few rates to cover different classes of customers, the rate book contains a multitude of rates.

Comparisons should probably be made between the electric and water industries concerning the seriousness of the fluctuations in demand that might suggest a need for demand-billing practices. A water utility can generally store enough water in its distribution system to take care of short-term variations in load. The electric industry, on the other hand, cannot. Reasonable pressure variations are not serious in a water system; the pressure might, for example, vary between 40 and 60 psi with no complaints from customers. In the electric industry no such variations could be tolerated. Voltage must not be allowed to vary more than a very tiny amount from normal.

The electric industry is also more competitive than the water supply industry. Competition with other power and fuel utilities is one of the principal reasons that electric utilities have changed to demand rates. The use of demand rates has allowed them to lower their charges and enable electricity to compete favorably with other sources of energy. Even the water supply industry has been affected by this, in that the lower power charges possible under demand billing have caused most water utilities to abandon steam or internal-combustion engines in favor of electric power.

Need for Study

In discussing the need for demand meters, the author assumes that a demand meter for water would be similar to the two basic types used by electric utilities—that is, that it would be either an "indicating" meter, from which the

highest demand in a selected interval in the period between meter readings could be obtained by the meter reader, or it would be an "integrating," which either prints or shows graphically the consumption in selected intervals of 15 min, 30 min, 60 min, or 24 hr.

It has been suggested that if the meter manufacturers were to produce demand meters at a reasonable cost the water industry would, perforce, use them. The author disagrees with this assumption. If the water industry, or any noticeable segment of it, wished to utilize demand billing to any significant extent it would already be doing so with presently available equipment. Although the available equipment is not inexpensive, its cost could certainly be justified if large water users really needed to be billed on a demand basis.

The author does not believe that there will be any commercial market for demand meters of the types used in the electric industry until the water industry has developed a basis for utilizing the records such meters would produce. The St. Louis County Water Co. might purchase half a dozen additional demand-recording attachments for use in its 147,000-customer system if the units were priced at $100 or less and could operate for weekly or monthly periods. The instruments would be used for customer demand information, but would not be used for demand billing in the foreseeable future. They would be used only because they would be less expensive than the equipment presently available.

The author suggests that AWWA, or one of its committees, collect information concerning all current demand-billing practices, including those based upon estimated demands, readings of ordinary meters, or the use of recording instruments.

The water industry will probably not find it desirable to adopt the complicated demand-billing practices used by the electric utilities; they may adopt simpler procedures that will encourage customers to eliminate undesirable peak demands or will cause such customers to pay a penalty for imposing abnormal demands on the system.

References

1. Delvaille, G. C. What Does the Rate Engineer Do? *Pub. Utilities Fortnightly* (Jun. 19, 1947).
2. Caywood, R. E. *Electric Utility Rate Economics.* McGraw-Hill Book Co., New York (1956).

Marvin E. Hartz

Director of Research & Eng., Badger Meter Mfg. Co., Milwaukee, Wis.

Generally, the investments necessary for supply, treatment facilities, pumping plants, and distribution are determined by the imposed demand. In order to establish equitable rate structures that apportion charges according to the capital investment required for supply and distribution capacity it is necessary to obtain records of consumer demand. Demand-metering equipment is the logical tool for the formulation of equitable rate structures and for fair apportionment of charges for system expansion and improvement. Furthermore, demand metering equipment can make available a method to give credit, by offering a lower-cost commodity, to the customer who maintains a good load factor, or, in other words, a relatively even demand rate.

Need for Uniformity

Rate structures that are based on the load factor have been employed by electric utilities for many years. The theory and application of demand rates

and the design of instrumentation to measure demand have been reasonably well standardized in electric-power practice. This is not true in the water supply industry. Although several water utilities have applied demand charges, there is no general agreement on methods of applying rates or on instrumentation requirements.

The lack of uniformity in approach to the application of demand charges becomes very apparent when one reviews surveys made of water utility people on this subject. Several methods that have been proposed, and in many instances employed, to establish demand rate structures are:

1. Imposition of surcharges on hose bibs, the number of taps, and underground irrigation systems
2. Application of tonnage charges on air-conditioning installations
3. Basing of rates on the size of meter so as to establish a higher rate for larger meters
4. Use of demand-recording or demand-indicating instruments on all classes of services to gain demand data
5. Application of higher commodity rates to domestic consumers because of the high service cost of supplying and maintaining these services and the application of a two-part tariff consisting of a demand and a more reasonable commodity rate to commercial and industrial services.

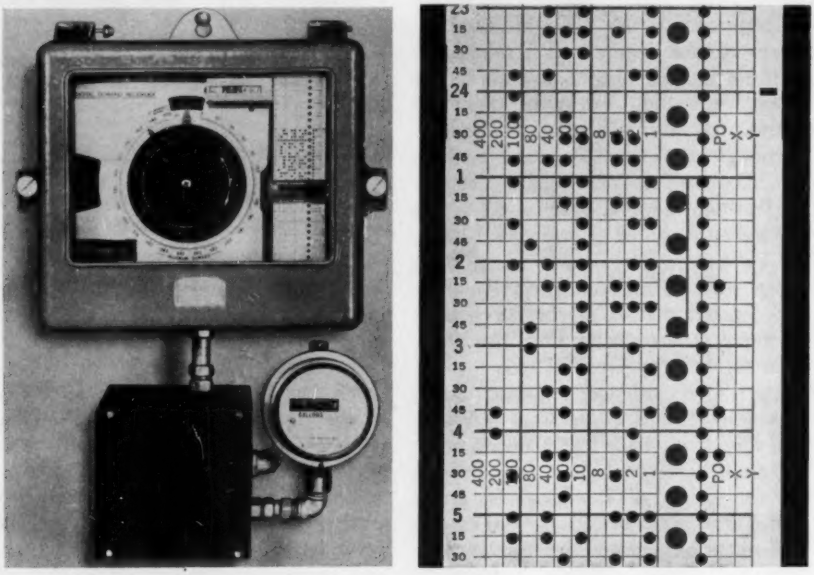

Fig. 3. Demand Period Totalizer and Receiver and Recorder Tape

Impulses from a totalizing meter are recorded on a punched-tape chart which can be read or processed on automatic data-processing machines. A closeup of the tape is shown in the right panel.

The diversity of these methods presents a real problem to the prospective manufacturer of metering instruments. Obviously, the employment of certain

of these schemes does not require any type of demand instrumentation. Those methods that do involve instrumentation have widely different equipment design requirements. Therefore, it is necessary to evaluate carefully the practicability of each of the proposed approaches and determine which one or ones are most likely to have widespread application. Standardization, both in method of applying demand charges and in the design of the instruments used to measure the demand, is vital if the manufacturer is to make an intelligent evaluation of the technical feasibility, size of market, position of competition, methods of distribution, and cost of producing demand-metering equipment.

Prototype Equipment

Many water utility officials and government agencies are becoming increasingly interested in rate policies involving the two-part tariff. A typical example is Milwaukee. By a 1958 decision of the Wisconsin Public Service Commission, Milwaukee was permitted to install instrumentation to determine extra capacity charges for wholesale-service. Through the cooperation of engineers of the Milwaukee utility and the author's firm, specifications were developed for demand period instrumentation. A prototype of this equipment was produced and installed on an 8-in. service supplying the suburban community of Wauwatosa, Wis. This prototype equipment is shown in Fig. 3.

Figure 3 is a front view of the demand period recorder mounted on a panel. The remote totalizer and the receiver mechanism for the recorder are mounted on the lower section of the panel. The demand period recorder produces a punched-tape record which combines easy readability and automatic-processing capabilities. Impulses from a totalizing meter are transmitted to the receiver and fed into the recorder, where they are mechanically stored for the demand interval. At the end of each demand interval, a punching and reset mechanism code-punches the recorder tape.

Figure 3 also shows a section of the tape produced by the recorder. The tape is time-printed along the left margin. Readings are spaced $\frac{1}{8}$ in. apart, and the tape can accommodate 10,000 readings. An individual demand reading appears as a single horizontal punched line in a standard binary-decimal code that represents the integrated pulse storage at the instant of reading. Maximum readings may be visually selected from a length of tape, because higher readings contain punches in the high-numerical-value columns of the tape. Automatic equipment is available to convert the data of the demand interval tape to punched cards, which makes automatic processing of demand information possible.

Attached directly to the water meter is a meter-energized generator, which transmits pulses to the remotely located totalizer and receiver. Inputs to the chart recorder mechanism are provided by a low-voltage–pulse generator, or two generators for compound meters. The pulse generator is mounted on the meter and provides pulses in exact conformance to the flow through the meter. The low-voltage pulses are transmitted by a simple two-wire system to a remotely located receiver, which is installed adjacent to the recorder mechanism. The function of the receiver mechanism is to translate the low-voltage pulse into line voltage pulses compatible with the electrical-input requirements of the recorder.

Conclusion

The equipment developed for the Milwaukee system was specifically designed for measurement of demand of the larger, wholesale customer. The size of billings to this class of customer economically justified the cost of this type of equipment.

If there is to be widespread employment of demand-metering equipment on the smaller commercial services—or possibly even on domestic services—simpler and less costly equipment will be required. The demand instrumentation requirements of the water supply industry can be met by meter manufacturers. The development of the equipment for the Milwaukee system is an example of cooperation between industry and the utility. Sufficient evidence of the need for and feasibility of a new product must be available to a manufacturer before he can be expected to invest the capital and facilities of his company in it. A concerted effort by the water supply industry to establish standards for the application of demand charges and for the design of instrumentation will accelerate the development of a type of demand measurement equipment that will satisfy the requirements of the greatest number of water utilities.

Winthrop P. Hersey

President, Hersey Mfg Co., Dedham, Mass.

Nearly 10 years ago AWWA directed attention to the possibile need for demand metering equipment. For some reason the idea never caught fire throughout the industry, although there must have been those who thought such a device would be a valuable and needed instrument.

Various articles have appeared in the JOURNAL indicating that demand charges have been imposed in certain cities for water used at excessively high flow rates. Various principles and policies have been evolved for charging for water service, and instruments have often been used to determine the water use patterns upon which charges are based.

The author's firm began to work actively on this subject about 5 years ago, when it was asked to produce an inexpensive device for indicating the maximum flow rate that occurs in a service in a definite time interval, such as a week or month. Some time later another customer asked the firm to develop a meter that would register all of the water that passed through the meter, regardless of the rate of flow, and, in addition, register separately only that water which passed through at higher than a specific, predetermined flow rate. A number of such devices were designed and placed in service for field trial. The registers were of the ordinary mechanical type and did not involve chart recorders or require electric power. Field tests have been very encouraging, and the device can be installed on meters presently in service.

Potential Market

In 1956 a consulting firm was employed to study the market possibilities for the device described above. The survey was countrywide in scope and produced much data, even though the interviewers revealed very little information about the operating principle of the metering device. Just what effect this semisecrecy had upon the results of the study is hard to determine. The final opinion of the consultants in 1956 was that very little thought had been given to the handling of water demand problems on a basis that would make a demand meter

applicable. They considered it doubtful that an extensive market would develop in the foreseeable future. According to the survey, it was the tendency of utilities to expand their facilities and divide the attendant costs equally, rather than to conserve and make better use of existing facilities. Nevereless, the survey made it clear that a reasonable number of water utility men are interested in the subject and have opinions concerning the value of demand metering, although few have taken any action to foster the principle in their areas.

One water supply official expressed the opinion that the operators must determine what kind of water use information they need and then enlist the meter manufacturers to build suitable devices to satisfy the need.

The author's firm is now engaged in the design of demand meters involving chart recorders which can be installed either permanently or temporarily and can be operated either mechanically or electrically. Although much time is required to analyze charts, it is justified, when extensive information is required, to study the varying water use patterns of different services. When the study of a service or group of services has been completed and a demand charge billing factor has been established, a less expensive direct-reading meter could be used without seriously complicating the regular meter-reading procedure.

Flow Rate Measurement

In determining whether or not a service should be equipped with a permanent demand meter, a utility might employ one of several methods to determine the peak flow rate:

1. A device is available that can be placed on an ordinary meter and will convert the reading of the initial dial of the meter register into an arc scribed on a chart and represent an equivalent volume. It does not indicate the highest instantaneous flow rate, unless the flow rate was constant. With a reasonable amount of judgment, an idea of the water use pattern can be obtained.

2. A simple method for making a preliminary determination of the highest flow rate in a service is to use pressure gages with loose resettable pointers at each end of a disc or current meter. The pressure differential shown on the gages can be located on a meter pressure loss chart and the corresponding rate of flow is thus easily determined. This method cannot be applied to compound or fire service meters because the pressure drop is not linear. Owing to the interaction of main-line and bypass sections the same pressure loss may appear at two or more flow rates.

3. Portable, spring-wound chart recorders can be used to indicate variable flow rates by recording instantaneous pressure differentials across orifices or meters during peak flows.

Conclusion

Efforts are continually being made to develop demand-metering equipment that can play an important part in any demand charge program that may be inaugurated in the foreseeable future. It now looks as though two distinct types of demand-metering equipment will be required: [1] one type, probably of the recording chart variety, to determine the need for demand charges and [2] another for permanent installation in places where high-demand conditions are known to exist. It will be necessary, however, for utility men to determine just what type of information they expect from a demand meter.

Joseph F. O'Grady

Product Mgr., Water Meter Div., Rockwell Mfg. Co., Pittsburgh, Pa.

Since the turn of the century, the author's firm has been manufacturing instruments for demand metering in the gas industry. These instruments are easily adaptable to liquid flow. The present gas demand meters record total volume flow rate, and pressure. The timing mechanism in the instrument is capable of furnishing records on hourly, daily, weekly, semimonthly, or monthly charts.

Although conversion from gas measurement to water measurement would be relatively simple, it is not yet certain what kind of meter will be required by the water industry. Manufacturers need general specifications in order properly to direct their research activities toward the development of an ideal design.

When a manufacturer begins to investigate the possibility of making and selling a new product, he follows definite lines of procedure. For an approach to demand metering for water, the author's firm is first investigating basic ideas that suggest themselves automatically from past experience in the manufacture of demand meters for electric power and for gas. These ideas are also being correlated with the results of a recent survey of water utility men in which it was asked what the water supply industry wants of a demand meter. The object of all these activities is the development of an instrument that can be attached to all standard types of water meters. Such an ideal may not be reachable, of course, because high manufacturing costs may automatically make such a demand-recording instrument too expensive for most utilities. If this happens, as it does with many new products, the next step will be to develop a set of specifications for a more practical design—one that can do the most for the greatest number of customers and can be sold at a reasonable price.

Some of the things that remain to be determined are:

1. What can and cannot be accomplished with various suggested designs
2. How many parts and what kinds of materials can be considered
3. The ease or difficulty of manufacturing various designs
4. What assembly and maintenance problems are likely to arise
5. Overall production costs of various designs
6. What utilities are willing to pay.

Once these things have been established, it will be possible to estimate the actual selling price and sales volume. Preliminary figures, for example, indicate that a gas demand meter converted for water service would sell for approximately $200. The manufacturerer's problem is to determine whether there can be a market for such a meter at that price. An industrial company must, after all, sell its products at a reasonable profit to remain in business.

Before demand metering can ever become a widespread technique in the water supply industry, there must be much more discussion of the features required of a demand meter. Manufacturers must be told where such equipment will be installed, and what kind of meters are necessary for installations other than large air-conditioning units and other seasonal users of water.

The author's firm is very interested in the potential market. The responses to the survey mentioned above gave the firm's engineering staff and laboratory many useful ideas, and showed that there is widespread interest in the problem.

High-Rate Treatment of Water Supplies

E. Sherman Chase

A paper presented on May 4, 1959, at the Canadian Section Meeting, Montreal, Que., by E. Sherman Chase, Partner, Metcalf & Eddy, Boston, Mass.

METHODS for increasing the speed of water treatment received their first significant stimulus in the mid-1890's with Fuller's classic experiments at Louisville and Cincinnati. These experiments led to the development of the modern rapid sand filter, preceded by chemical and physical pretreatment facilities. The development of the rapid filter and its wide range of application led to the end, with a few exceptions, of slow sand filter installations. The next important step in the speed-up process can properly be attributed, in large measure, to the pioneer work in chlorination by Houston in England and Johnson in the United States, shortly after the turn of the century. Chlorination freed filtration of the responsibility for bacterial removal and thus permitted a speedup.

Although not so far reaching or as epochal as these earlier developments, the work of Baylis at Chicago during the past decade has demonstrated that, under certain conditions at least, rapid sand filters can be operated with satisfactory results at substantially higher rates than has been accepted practice. Baylis reports that a 10-year test has proved that rates of filter operation greater than the conventional 2 gpm/sq ft of filter area could be used with Lake Michigan water at Chicago. Ten of the 80 filters at the Chicago South District Filtration Plant were operated successfully at rates of 4–5 gpm/sq ft.

It should be noted that Baylis' results were obtained with Lake Michigan water, and although the results have been eminently satisfactory, it cannot be assumed at this time that equally satisfactory results can be obtained with all kinds of water and under different conditions. The Chicago results do indicate that designers of filter plants should investigate carefully the applicability of high rates of filtration to the types of raw water with which they are concerned. Where applicable, the adoption of higher rates may well mean savings in money and space. One of the reasons for the success at Chicago is the fact that exceptionally close control of the raw water was developed and maintained prior to its application to the filters.

Pretreatment and Filtration

The original purpose of the slow sand filter was the physical removal of silt and debris from muddy and debris-laden waters. Eventually, with the establishment of the germ theory of disease, the removal of bacteria became a second objective. Both objectives could be obtained with the slow sand filter, but it was limited with regard to the type of water it could handle at practical rates. To extend its usefulness, pretreatment facilities—such as sedimentation basins and

roughing filters of coarse media—were frequently installed. Such facilities may be considered as the beginning of the pretreatment now developed to a high degree.

Rapid filters, from the beginning, have depended to a considerable degree upon adequate preparatory treatment of the raw water. Such preparation has involved coagulation with chemicals and sedimentation. The filters then strained out residual suspensions of solids, bacteria, and algae. Coincident with such treatment, a third objective for purification devices became possible—namely, the removal of color from colored waters.

From time to time, experience and science have produced improvements in the art of water treatment. All of these improvements have had the effect of accelerating treatment without impairment of the quality of the final product. Baylis' work in improving pretreatment by use of a specifically prepared silica gel as a coagulant aid is an example. Without such improved pretreatment, the results that Baylis has obtained with high-rate operation of his filters would not have been possible.

Among the sundry improvements that have occurred over the years are rapid or flash-mix of chemicals with incoming raw water, gentle flocculation by mechanical means, and good clarification by sedimentation basins. Such practices have resulted in marked reductions of the amount of matter to be strained out by subsequent filtration and in effective color reduction. Although not quite accomplishing the original objective of filtration—namely, the removal of all matter in suspension from the raw water—efficient pretreatment greatly reduces the load on filters.

When chlorination began to be used, the second objective of filtration—bacterial removal—became of secondary importance. Filtration is depended on less and less for bacterial removal, and chlorination more and more. With a process as easily controlled as chlorination, it is far less important to operate filters at the rates established when bacterial removal by filtration was of primary importance. Thus, filters have become refining and safety devices and can be operated without fear of excessive bacterial content in the finished water.

Upflow Basins

Where softening of hard waters is practiced, the use of upflow settling basins—in which the chemically treated water passes upward through a sludge blanket of precipitated lime salts—permits a shorter time of passage than that needed with conventional tanks. The upflow basin is less applicable with soft waters, in which coagulated flocs are too near the specific gravity of water to settle readily against upflow currents; hence, this type of basin is best adapted for softening hard waters.

Microstrainers

The microstrainer, developed within the past 10 years, provides a purely physical and mechanical means of rapidly removing suspended matter and algae. This device consists of a steel cylindrical frame, covered with a stainless-steel woven-mesh cloth backed up by a heavier, larger-mesh screen. The raw water enters within the cylinder and is strained through the mesh into a well surrounding the microstrainer. The cylinder revolves slowly, so that the areas of wire cloth on which material has accumulated are sprayed with water as they reach the

top of the path of rotation. The sprays flush the accumulated material into a trough and then to a waste receptacle.

The use of microstrainers in England has been confined largely to the preparation of algae-laden stored waters for application to slow sand filters. For example, at the new Ashford Commons filtration plant of the London Metropolitan Water Board, microstrainers ahead of the slow sand filters are installed in lieu of rapid sand filters, such as are used at some of the other water board installations.

The potential field of usefulness for microstrainers appears to be limited to the treatment of stored waters subject to algae growths or suspensions of amorphous matter at times of overturn. At Danvers, Mass., a pilot plant, consisting of a small microstrainer and an ozone generator, successfully treated a soft, colored pond water subject to growths of algae.

High-Rate Filters

Although Baylis successfully operated filters at rates as high as 5 gpm/sq ft, he points out that in order to provide for peak demands it is wise to design for average rates of 3 gpm/sq ft. To permit rates higher than those conventionally used, the effective size of the sand constituting the filter bed should be greater than has been used in the past. With the high-rate operation, an effective size of sand of 0.65–0.70 mm should be specified.

Inasmuch as some penetration of the sand bed with floc passing the sedimentation basin may occur, it is wise, at least in large plants, to provide some form of surface wash with either movable or fixed jets. Furthermore, high-velocity wash is desirable to provide approximately 50 per cent sand expansion.

Experience at Chicago indicates that, other conditions being equal, the length of filter runs is, roughly, inversely proportional to the rate of filtration. The percentage of wash water required is about the same irrespective of the rate of filtration, although the percentage may be a little greater with the higher rates.

Numerous factors relating to the water to be treated need to be taken into consideration in setting design criteria. Among such factors are temperature, turbidity, alkalinity, algae, and types and degree of pollution. Particular attention must be given to variations in these factors and the suddenness with which they are liable to occur. Plants treating waters of fairly uniform characteristics require fewer factors of safety in design than those plants that can expect big and sudden changes in the quality of the raw water. This is particularly true where pollution is one of the conditions to be dealt with.

As Baylis points out, the effective preconditioning and clarification of the raw water accounts for the success of high-rate filtration at Chicago. Coagulant aids, such as bentonite and activated silica, have been of primary importance for effective pretreatment in numerous instances. Methods of preparing activated silica have varied, involving the use of sulfuric acid, chlorine, and other materials.

Although the cost of high-rate filters, per unit volume of water treated, will be lower than that of standard-rate filters, the cost of preparatory facilities will not be affected. Neither will the cost of influent, effluent, and wash water piping and drains be greatly reduced. The main saving will result from the need for fewer filters and their appurtenances. Operating costs

are likely to be about the same, although with large plants there may be some slight saving in labor.

Summary

Before adopting any form of high-rate treatment, careful study should be made of the characteristics of the water to be treated. Particular attention should be paid to the kind and amounts of conditioning chemicals adapted for the particular water involved. It is a well accepted theorem that adequate pretreatment is the key to successful high-rate filtration.

The main value of clarification basins using the sludge blanket principle of solids-contact and upflow, lies in the shorter detention periods and smaller tanks or basins required. This type of basin, however, is best adapted to softening processes where the blanket of precipitated solids is relatively heavy and not subject to convection and other disturbing currents.

Microstrainers appear to have limited value in North America, except where the water to be treated needs only straining and disinfection. They do offer promise where the raw water is derived from storage reservoirs or ponds and, except for algae and suspended amorphous matter, is of good natural quality.

The adoption of high-rate treatment is a matter of considered judgment based upon experience and knowledge of the particular conditions to be met. Adequate pretreatment is essential and much reliance must be placed on chlorination. With these provisos, high-rate treatment is here to stay.

Correction

The article by Floyd F. Davidson, "Poisoning of Wild and Domestic Animals by a Toxic Waterbloom of *Nostoc rivulare* Kuetz" (October 1959 JOURNAL, Vol. 51, pp. 1277–1287), contained an incorrect statement. On p. 1285, in col. 2, line 21, the phrase "increase in the rate of heartbeat" should read "*decrease* in the rate of heartbeat."

Progress Toward a Filtrability Index Test

Task Group Report

A report of Task Group 2720—Filtrability Index Test, presented on Jul. 14, 1959, at the Annual Conference, San Francisco, Calif., by Joseph M. Sanchis (Chairman), San. Engr., Dept. of Water & Power, Los Angeles, Calif. Other members of the committee are Jack E. Awde, Clayton M. Bach, Jack A. Borchardt, Eugene Bowers, John F. Dye, Douglas Faben, Merrill B. Gamet, Oscar Gullans, Harry N. Lowe Jr., DeLoss H. Matheson, J. Robert Popalisky, and Percival L. Boucher (consultant).

AS a result of a discussion at the reorganizational meeting held at Dallas in 1958 by AWWA Task Group 2720—Filtrability Index Test, it became apparent that it was time to stop, look, and listen in order to appraise what had been done on methods of determining water filtrability and to evaluate the results so far obtained in order to direct future experimental work into fruitful channels.

Filtrability

"Filtrability" has been defined as the ease with which a water can be passed through a given filter. The term "filtrability index" was introduced by P. L. Boucher (*1*) in British water supply literature as a means of expressing in mathematical terms the blocking effect produced by the accumulation of suspended matter on a given filter during the water filtration process. Also mathematically, Boucher defined filtrability as the reciprocal of the filtrability index.

Those responsible for the management of filtration processes, as well as those engaged in design, have felt keenly the need for a suitable experimental method of measuring water filtrability as an aid to better filter operation control and to the prediction of filter media requirements. For this reason there have been many attempts in the past to develop such a procedure.

Measuring Methods

The methods used to measure water filtrability fall into two general groups: [1] those based on variable-flow measurements under constant head, and [2] those based on variable-head measurements under constant flow. Each of these groups can be subdivided into two more types depending on the manner in which the sample of water is passed through the test filter—that is, with intermittent flow or with continuous flow (Fig. 1).

These basic procedures have been further modified through the use of various types of filter media and by modifications in technique to improve test performance or to satisfy special requirements.

Perhaps one of the first attempts to define quantitatively the filter-clogging properties of natural waters by means of a laboratory test was described by Alexander Houston (*2*). Essentially, the procedure consisted of measuring the volume of filtrate obtained in 1 min from tap water passed under a

constant head through a small linen filter which had previously filtered 100 ml of the water being tested. The most serious drawback of this method is the difficulty of duplicating "standard" cloth membranes and tap water quality.

In 1943, E. V. Suckling (*3*) expressed filtrability as the ratio of the time taken for 1 liter of distilled water to pass through a filter paper under standard conditions to that required to pass 1 liter of the test water through

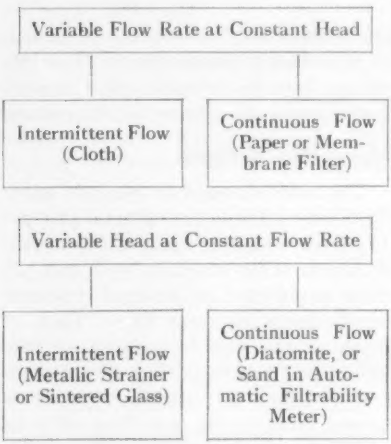

Fig. 1. Typical Procedures for Determination of Filtrability of Water

a similar filter paper under the same conditions. Again, lack of uniformity in filter paper texture detracts from the usefulness of this procedure.

Modifications of this method using molecular filter membranes have been attempted in the past and are being actively studied at this time in connection with the Lake Michigan water filtration studies and at the experimental water treatment laboratory of the Los Angeles Department of Water and Power. The apparatus used at Los Angeles is shown in Fig. 2. As the filtering area has been standardized in this type of filter, the filtrability of the water being tested may be conveniently expressed as the number of milliliters filtered in 5 min into a cylinder maintained at a constant vacuum of 7.5 in. of mercury.

The use of membrane filters to determine the clogging tendency of waters used for subsurface injection in the secondary recovery of oil deposits by petroleum producers was described in 1957 by Doscher and Weber (*4*). These authors mentioned the following attractive features of membrane filters:

1. Available in a variety of uniform pore sizes (5 $m\mu$–5 μ)
2. Have 80–90 per cent porosity and therefore allow high flow rates per unit pressure drop, even when those with very fine pores are used
3. Composed of cellulose esters which are ashless on ignition and completely soluble in some organic solvents
4. Have uniform index of refraction (1.49–1.51) and are rendered transparent with immersion oil for microscopic examination of the filtered particles.

In another procedure attributed to F. Greenshields, senior biologist with the Metropolitan Water Board, the loss of head through a standard sintered-glass filter was measured while it was filtering tap water at a standard rate of flow, before and after a given volume of the water being tested was passed through the filter. The inverse of the difference, or the ratio between the loss of head across the filter before and after the passage of the sample, was taken as a function of filtrability. Among the shortcomings of sintered-glass filters are the lack of pure size uniformity in commercially available filters and the ease in which their per-

meability can be affected by the lodging of solids in the body of the filter.

Boucher's Theory

The procedure described above was improved by Boucher, who, in a thesis completed in 1944 (*5*), described his experimental investigations into the hydraulics of filtration undertaken to solve certain engineering problems in

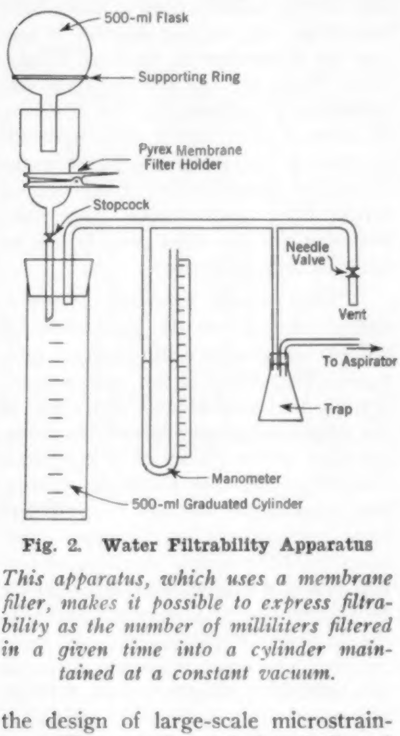

Fig. 2. Water Filtrability Apparatus

This apparatus, which uses a membrane filter, makes it possible to express filtrability as the number of milliliters filtered in a given time into a cylinder maintained at a constant vacuum.

the design of large-scale microstrainers. His experimental data indicated that, under certain conditions of filter operation, the rate of increase of hydraulic resistance with respect to the volume of water filtered is proportional to the hydraulic resistance:

$$\frac{dH}{dV} = nH \ldots\ldots\ldots (1)$$

Integrating and solving for n, Boucher arrived at the following expression:

$$n = \text{Filtrability Index} = I = \frac{1}{V} \log_e \frac{H}{H_0} \ldots (2)$$

in which n and I denote the filtrability index with respect to the filter, H_0 is the initial head loss of the filter and H the head loss after the passage of a volume of water V. The values of H_0 and H are measured at the same rate of flow and in the same units. If the volume is expressed in cubic feet per square foot of filter area, I is a measure of the rate of increase of hydraulic resistance of the filter after the passage of 1 cu ft of water through 1 sq ft of filter area (Fig. 3).

The filtrability index apparatus used by Boucher is shown in Fig. 4. The filter medium most frequently used in this type of apparatus is a stainless-steel woven fabric mounted on a circular brass holder. The diameter of the "standard" filtering surface is $\frac{1}{2}$ in., and the nominal pore size of the strainer is 15 μ.

Diatomite Experiments

Boucher's theory came to the attention of members of the Los Angeles Department of Water and Power in 1948, while they were attempting to find a parameter more reliable than the turbidity of the raw water for the prediction of optimum body feed doses in diatomite filtration (*6*). His theory was tried by the use of a miniature diatomite filter which contained a single element of 0.18 sq ft of filter surface area.

After precoating the miniature filter element with the type and amount of diatomaceous earth which had proved most effective for use in the larger

experimental filter element* (¾ oz per square foot of filter area), the filter was placed in operation, filtering the water under test at a constant rate of 5 gpm/sq ft. Head loss readings were taken 3, 5, and 10 min after the start of the miniature filter run. From the known rate of flow and time between head loss readings, the volume V was determined and the filtrability

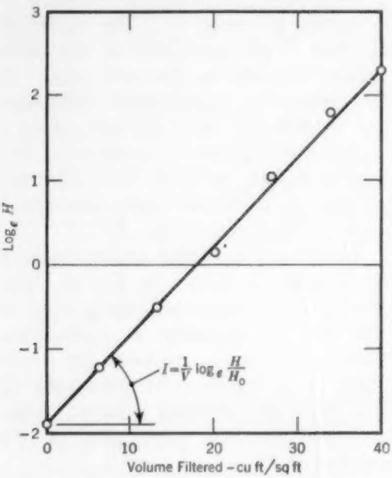

Fig. 3. Determination of Filtrability Index

The filtrability index is represented by the slope of the plot of volume filtered per unit filter area against the logarithm of head loss (in feet). The curve is based on Boucher's equation (Eq 2).

index was then computed by Boucher's formula.

The experimental data indicated a better correlation between the filtrability index results and the optimum body feed doses, as obtained by the lengthier sag curve procedure, than it was possible to obtain with turbidity measurements. It must be kept in mind, however, that the purpose of the experimental work at Los Angeles was to determine the applicability of diatomite filtration to the clarification of plankton-bearing waters without chemical pretreatment.

* Celite, JM No. 545; a product of Johns-Manville Corp., New York.

Need for Standardization

The procedures previously described and several modifications of them have been tried with varying degrees of success by a number of workers (*7–12, 14*). From the accounts of their experiences, it appears that the diversity of views held by those who have attempted to apply the results of water filtrability tests to the prediction of actual filter performance may have been due, for the most part, to one or more of several causes:

1. The natural tendency to overextend the sphere of application of procedures designed for special purposes (Filtrability is not only a function of the amount and character of the suspended matter carried by water, but also of the ability of a particular filter to retain that material. Therefore, procedures devised to predetermine performance of filtration processes involving simple straining of certain types of suspended matter cannot be expected to be always applicable to the forecast of performance in more complex processes involving filtration of chemically treated waters through heterogeneous beds of granular material.)

2. The lack of an adequate yardstick for measuring the performance of operating filters (To be realistic, any such yardstick must take into consideration the quality of the filtered water (*13*); a long filter run obtained under actual operating conditions may merely be the result of a breakthrough that

permits a considerable amount of suspended matter to pass through the filter. Without a suitable reference standard, it is not possible to correlate the results of water filtrability tests with actual filter performance.)

3. The need to take into consideration temperature variation effects in the performance of water filtrability tests as well as in the expression and interpretation of results. (Experience

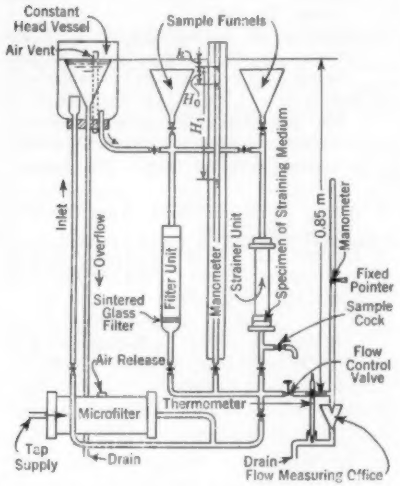

Fig. 4. Boucher Apparatus

In this apparatus, a stainless-steel fabric or a sintered-glass filter of suitable pore size may be used.

shows that even the ordinary temperature fluctuations met under normal operating conditions seem to have considerable influence in the results of filtrability determinations as well as in the performance of operating filters. The effect of temperature changes on the flow of water through filters is quite complex, inasmuch as it not only affects the viscosity of water but also influences the behavior of suspended matter, the equilibrium of dissolved gases, and chemical reactions.)

It appears, therefore, that the most urgent need is the standardization of a method for expressing the overall performance of operating filter units in order to make possible an evaluation of water filtrability procedures. To be effective, this method must take into consideration the quality of the water in the filter effluent.

Filter Performance Index

In their study of treatment plants filtering Lake Michigan water, Gamet and Rademacher (*14*) have used as an index of filter performance (FPI) the volume of water filtered per square foot of filter area during a run per foot of terminal head loss:

$$\text{FPI} = \frac{\text{filtration rate (gpm/sq ft)} \times \text{length of filter run (min)}}{\text{head loss at end of run (ft)}}$$

The quality of the effluent water could be introduced as a factor in an expression of this type by limiting the length of filter run to the time it takes for the quality of the filter effluent to reach a predetermined level of deterioration. This level could be detected turbidimetrically or by filtrability test determinations.

Conclusion

There is reason to believe that a water filtrability test utilizing molecular filter membranes (see Fig. 2) could find a most useful application in the determination of filter effluent quality. The sensitivity, reproducibility, and simplicity of this test, as well as the possibility it offers for the recovery and microscopic examination of material accumulated on the membrane, give it definite advantages over turbidity measurements in evaluation studies.

Experimental work to establish a standard filter performance test embodying the considerations set forth in the foregoing and the experimental determination of temperature variation effects on filtrability determinations appear to be two most urgent and worthwhile projects at the present time.

References

1. Boucher, P. L. A New Measure of Filtrability of Fluids With Applications to Water Engineering. *J. Inst. Civil Eng.*, **27**:415 (1947).
2. Houston, Alexander. 17th and 18th Annual Reports, Metropolitan Water Board, London.
3. Suckling, E. V. *The Examination of Water and Water Supplies.* J. Churchill Ltd., London (5th ed. 1944).
4. Doscher, T. M. & Weber, L. The Membrane Filter in Determining Quality of Water for Surface Injection. *Producers Monthly*, **21**:32 (Jun. 1957).
5. Boucher, P. L. Straining of Water and Effluents—An Experimental Study of Engineering Problems Encountered in the Design of Large-Scale Automatic Straining Plant for Water and Effluents. Thesis, Faculty of Engineering, University of London (1944).
6. Sanchis, J. M. & Merrell, J. C., Jr. Studies on Diatomaceous-Earth Filtration. *Jour. AWWA,* **43**:475 (Jul. 1951).
7. Matheson, D. H. Improved Water Filtrability Test. *Wtr. & Sew. Wks.,* **101**:517 (Dec. 1954).
8. Baker, R. J. Engineering Report on Filtrability. Wallace & Tiernan Inc. (*unpublished*).
9. Bowers, E. Private Communication (Aug. 23, 1957).
10. Gullans, O. & Davoust, N. J. Comments on Filtrability Index Experiments. City of Chicago (*unpublished*).
11. Borchardt, J. A. The Application of the Filtrability Index to Filtration. Paper presented before the Michigan Section AWWA Sep. 1958 (*unpublished*).
12. Awde, J. E. Private Communication (Jun. 18, 1959).
13. Hudson, H. E., Jr. Factors Affecting Filtration Rates. *Jour. AWWA,* **48**:1138 (Sep. 1956).
14. Gamet, M. B. & Rademacher, J. M. Measuring Filter Performance. *Water Works Eng.,* **112**:117 (1959).

Current Research on Coagulation

A. P. Black

A report presented on Jul. 15, 1959, at the Annual Conference, San Francisco, Calif., by A. P. Black, Research Prof. of Chemistry, Univ. of Florida, Gainesville, Fla. This report was prepared for AWWA Committee 2700 P—Advisory Committee on Research on Water Coagulation. The investigation was supported by Research Grant RG-4516 from the National Institutes of Health, USPHS.

RESEARCH grant RG-4516 from the National Institutes of Health, USPHS, is now in its fourth year of operation. With the aid of this grant, several aspects of the overall problem of water coagulation are being investigated.

Removal of Clay Turbidity by Alum Coagulation

The object of investigating the removal of clay turbidity by alum coagulation is to determine the effect of the base-exchange capacity of a clay on the amount of alum required for coagulation. Water suspensions of three clays with base-exchange capacities of approximately 10, 35, and 85 milliequivalents per 100 g, respectively, are being coagulated by varying amounts of alum. The resultant floc is being examined by electrophoretic methods to determine the change of the zeta potential of the particles. Removal of turbidity is being measured by the increase in light transmittance of the suspension after coagulation and settling of the floc. The clays used are Kaolinite 4, fuller's earth,* and Montmorillonite 23. Base-exchange capacity is determined by the standard ammonium acetate method for soils (*1*).

Work has been limited to Kaolinite 4 up to this time in an effort to obtain reproducible results. The natural clay has been ground and made up as a 1 per cent water suspension. This suspension is then passed through an ion-exchange column to replace the exchangeable cations with sodium and to give, therefore, more uniform particles (*2*). The resulting suspension of sodium clay is diluted to approximately 100 mg/l before coagulation tests are run.

It has been found necessary to add a salt to the clay suspension to give enough conductivity for electrophoretic measurements. Therefore, the suspensions for coagulation contain 50 mg/l sodium bicarbonate or sodium chloride. A specific resistance of somewhat less than 20,000 ohms is desirable for this experiment. Inasmuch as coagulation is greatly affected by the pH of the solution, samples are being tested in a pH range of 3–10.

After the salt is added and the pH adjusted with either hypochloric acid or sodium hydroxide, the sample is divided into two parts. One part is coagulated with alum on a jar test machine, and light transmittance is measured and compared with the

* Floridin, a natural unprocessed Florida fuller's earth, manufactured by Floridin Co., Warren, Pa.

transmittance before coagulation. The required amount of alum is added to the other part of the suspension. This is set aside overnight to allow the mixture to reach equilibrium. The mobility of the particles under an applied potential is then measured in a Briggs cell.

This work will be repeated with the other clays to see if there is any relationship between the base-exchange capacity and the amount of alum required to reach the point of zero mobility corresponding to a neutralization of the zeta potential. The effects of selected coagulant aids on mobility will be studied.

Polyelectrolyte Coagulant Aids and Color Removal

Because there are no data in the literature on the electrophoretic mobilities of the flocs produced when organic color is removed by coagulation with aluminum or ferric sulfate, much work first had to be done to accumulate these data. Two highly colored surface waters were selected, and each was coagulated with both alum and ferric sulfate. Floc mobilities were determined over a wide range of dosages and pH values. It was then possible to pick arbitrary points within the pH zones of coagulation of the two coagulants and to test the effects of various polyelectrolyte coagulant aids on electrophoretic mobility, color reduction, type and size of floc, and character of settling. For both waters and both coagulants a correlation was established between the pH zone of optimum coagulation and maximum color removal, and the mobility and zeta potential of floc particles. In almost every instance, either the isoelectric point or the point of maximum zeta potential occurred slightly before or within the optimum zone. Four coagulant aids were tested. One, a cationic material, was able to act as the sole coagulant and was able to reduce color and produce large changes in floc mobilities and zeta potentials. It was also effective as a coagulant aid for both alum and ferric sulfate, although it did not produce the large, dense flocs characteristic of some other aids. Two of the other aids tested were both anionic, and both produced large, dense flocs in low-dosage ranges and slightly improved color removal. The fourth coagulant aid, reported to be nonionic, had little effect either on floc characteristics or on color removal. An article presenting the results of this work is being prepared for publication in the JOURNAL.

TABLE 1

Analysis of Two Synthetic Waters

Synthetic Water	Constituents—*ppm*				
	Ca^{++}	Mg^{++}	Na^{+}	HCO_3^{-}	Cl^{-}
A	80	0	92	244	143
B	0	49	92	244	143

Coagulation of Sludges Formed in Lime or Lime-Soda Softening

Clarke and Price (*3*), in their studies of lime-soda softening, reported that both calcium carbonate particles and magnesium hydroxide particles bear positive electrical charges—more exactly, zeta potentials. About 5 years later, Larson and Buswell (*4*) reported that magnesium hydroxide particles are positive and calcium carbonate particles negative throughout the entire range of pH values encountered in lime-soda softening. They also stated that particles of hydrous

alumina are negatively charged for values greater than, and positively charged for values less than, pH 8.2. Corsaro and associates (*5*) reported the results of very careful measurements of the zeta potentials of particles of two commercial grades of calcium carbonate, one of very fine particle size and one of somewhat larger particle size. Using the microscopic method,* they found distilled water suspensions of both samples to be negatively charged, but found that both became positively charged after the addition of small concentrations of magnesium chloride. The charge on the sample of large particle size was changed from negative to positive by only 5 ppm magnesium chloride, whereas for charge reversal of the smaller particles a concentration of 63 ppm magnesium chloride was required. Information with respect to the sign of the zeta potential of colloidal particles of calcium carbonate and magnesium hydroxide throughout the entire pH range of lime-soda softening is essential in order to explain, among other things, the spectacular effect of activated silica as a coagulant in these situations. Accordingly, two synthetic waters have been prepared. Both have the same total hardness as calcium carbonate—namely, 200 ppm.

Synthetic Waters

Synthetic Water A was prepared from stock solutions of pure calcium chloride, dihydrate ($CaCl_2 \cdot 2H_2O$) and sodium bicarbonate. Synthetic Water B was prepared from sodium bicarbonate and magnesium chloride, which was prepared from 99.9 per cent pure magnesium metal.

Waters with any desired ratio of calcium to magnesium are prepared by mixing the necessary volumes of the two synthetic waters. The ionic constituents of the two waters are shown in Table 1. Both waters contain only monovalent anions in order to reduce the effect of such ions as much as possible.

Corsaro and associates supplied the author with samples of the two synthetic calcium carbonates † used in their studies and with four silica sols of known mobility. Electrophoretic measurements and techniques were checked with the aid of these known mobilities before the author's experiments were begun.

The following series of experiments, which have been or are now being conducted, use Synthetic Waters A and B, alone or in combination:

1. Synthetic Water A was softened with lime in the pH range 9.6–11.0, and the mobility of the precipitated calcium carbonate was determined as a function of pH.
2. Synthetic Water B was softened with sodium hydroxide in the pH range 10.0–11.0, and the mobility of the precipitated magnesium hydroxide was determined as a function of pH.
3. Several different mixtures of Synthetic Waters A and B are being softened with lime in the pH range 9.6–11.0, and the mobilities of both calcium carbonate and magnesium hydroxide are being determined. These data will yield information with respect to the effect of pH and the respective ions on mobility.
4. Synthetic Water A was softened with lime in the pH range 9.6–11.0,

* The equipment used was the Northrop cell, a product of Arthur H. Thomas Co., Philadelphia, Pa.

† Atomite and Purecal, products of Thompson Weiman & Co., Cartersville, Ga., and Wyandotte Chemical Corp., Wyandotte, Mich., respectively.

and the resulting sludge at six different pH values within this range was washed with water and suspended in distilled water. The particle mobility of each sludge was determined in the presence of magnesium chloride.

5. All of the above experiments are being repeated in the presence of varying dosages of activated silica and two coagulant aids,* in turn, to determine their effects on the particle mobilities of both calcium carbonate and magnesium hydroxide.

Nature of Organic Color

Saville (*6*), in an earlier and much quoted paper, using the crude electrophoretic techniques of his day, reported that most, if not all, of the organic color present in water is in the form of a negatively charged colloid. Several years later, Behrman, Kean, and Gustafson (*7*) attempted to answer the following questions with respect to organic color in water:

1. What is the chemical constitution of color bodies?
2. Are they present as colloids or in true solution?
3. Are they readily oxidized and degraded?
4. Are they organic or may they be in part inorganic in nature?

Using tea extract and solutions of alkaline pyrogallol, they found that the particles of these materials were negatively charged, but they made no exact observation on the color present in natural water. They found that little of the natural organic color would dialyze through a parchment membrane, indicating the colloidal nature of the organic color. They believed it to be organic in nature because the oxygen demand of the natural water, from which the color had been previously removed by coagulation, was significantly less than it was before the color was removed. They found that the color bodies act as indicators, decreasing in intensity at low pH values and increasing in intensity at high pH values. Finally, they found that most of the color could be oxidized by chlorine. None of these studies, however, gave any information with respect to the exact chemical nature of the color substances present in natural waters.

In a very important paper, Shapiro (*8*), working in the Osborne Zoological Laboratory at Yale, reported the results of an elaborate study of the yellow organic acids in the water from nine lakes in Connecticut, one in New York, and one in Wisconsin. Large samples of water were evaporated *in vacuo,* with temperatures never exceeding 45°C, and the dried residues acidified and extracted with various organic solvents. After further purification, paper chromatograms were run and photographed by long-wave ultraviolet light. Various types of absorption spectra were also obtained. Shapiro concluded that the organic color in water consists mainly of ultraviolet fluorescing dicarboxylic hydroxy

TABLE 2

Colors and Their Active Ingredients

Primary Color	Active Ingredient	Secondary Color	Active Ingredient
Red	$Fe(SCN)_6^{---}$	Orange	$Cr_2O_7^{--}$
Blue	$Cu(H_2O)_4^{++}$	Green	$Ni(H_2O)_6^{++}$
Yellow	CrO_4^{--}	Purple	MnO_4^{-}
			$Cr(H_2O)_6^{+++}$

* Separan 2610 and Jaguar, products of Dow Chemical Co., Midland, Mich., and Stein, Hall & Co., New York, N.Y., respectively.

aliphatic organic acids with an approximate molecular weight of 450. He concluded that the sharp zones obtained in his chromatograms were the result of various metallic salts of these acids and that if aromatic rings are present, as has long been supposed from the use of the term "tannic acid color," they are probably relatively unimportant. He found the materials to be quite stable. Organic extractions of the residue from freshly collected water were found to be identical with those of the same water allowed to stand unfiltered and in the light for 4.5 months before evaporating. Further, although refluxing with acid permanganate for 2 hr destroyed the color and fluorescence, it did not affect the infrared absorption spectrum. Finally, and most important of all, he found that the salts of the acids are dialyzable through cellophane membranes, indicating that these salts are not colloidal.

Shapiro's work is being repeated and extended with the use of two different highly colored surface waters obtained locally. In addition, with the cooperation of the boards of health of seventeen states widely separated throughout the country, samples of highly colored waters will be collected, including some of the same waters that Shapiro used. Those tests that have been found to be most informative will be made on these different waters in an attempt to determine what differences there are in the organic color bodies present in water in different parts of the country.

Determination of Turbidity and Color

Solutions of selected inorganic salts have been prepared in order to obtain standard solutions of the three primary and three secondary colors. The continuous absorption spectra of these solutions have been run between 350 mμ (3,500 Å) and 900 mμ (9,000 Å), using a spectrophotometer.* The solutions were diluted until the maximum absorbance did not exceed 0.50 in a 10-cm cell. The colors and their active ingredients are shown in Table 2.

Although the permanganate ion produces an intense purple color at extremely low dilutions, it is, unfortunately, not an adequately stable solution. It has been known for some time that the trivalent chromium ion in aqueous solution, in the absence of any complexing anion, produces a well defined standard purple solution. The work being done in this area is therefore being based on standard solutions of highly purified chromic nitrate. These solutions are being tested in a minimum tenfold range of concentration to check their conformity to Beer's law.

As mentioned before, highly colored surface waters will be collected from seventeen states throughout the country. Chromatograms of these waters will be taken to determine the optical properties of the colors present. It should then be possible, using mixtures of the standard inorganic primary and secondary color solutions, to prepare from these solutions a stable organic color standard that will more faithfully represent the nature of organic color present in water.

Specific suspensions of selected materials, which may be satisfactory for turbidity standards, have been prepared. Several different materials have been used. These suspensions will be mixed with the standard color

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* Beckman Model DK 2, a product of Beckman Instruments, Fullerton, Calif.

solutions in a wide range of ratios and their mutual effects determined. The data so obtained should provide information with respect to methods for determining organic color in the presence of turbidity, and vice versa.

Polyelectrolytes as Coagulant Aids

The author's first published article on polyelectrolytes as coagulant aids (*9*) reported studies of seventeen of these materials when they were used for the removal of clay turbidity only. The work has been continued, and twenty have since been studied as coagulants or coagulant aids in lime-soda softening; four have been studied as coagulants or coagulant aids for the removal of organic color with alum or ferric sulfate. Descriptions of this work will be incorporated in articles to be published.

Electrophoretic Techniques

Because there are three Briggs cells in constant use by several members of the author's research group, it seemed important to compare the accuracy and reproducibility of the results found by different workers in the same laboratory and those found by workers in different laboratories. Ritter, coauthor of the article referred to earlier (*5*), kindly agreed to supply the author's group with samples of four colloidal silica sols used in his laboratory, with values for the particle mobilities of each. These have been used in a very careful study of the various factors affecting both accuracy and reproducibility of electrophoretic data. The following conclusions have been reached:

1. The method used in cleaning and rinsing electrophoretic cells is very important. Scrupulous cleanliness must be observed if reproducible data are to be obtained.

2. The use of small concentrations, about 40–50 ppm, of potassium chloride or sodium bicarbonate as a conducting electrolyte greatly improves both the accuracy and the reproducibility of the results.

3. Neither workers in the same laboratory nor workers in different laboratories will be able to reproduce results unless they follow exactly the same methods and techniques throughout the determinations.

References

1. *Methods of Analysis.* Assoc. Offic. Agr. Chemists, Washington, D.C. (1955). Vol. 8, p. 39.
2. Lewis, D. R. Replacement of Cations of Clay by Ion-Exchange Resins. *Ind. Eng. Chem.*, **45**:1782 (1953).
3. Clark, L. M. & Price, L. S. The Role of Sodium Aluminate in Accelerating the Separation of Solid Phases During Water-Softening Operations. *J. Soc. Chem. Ind. (London)*, **52**:35 (1933).
4. Larson, T. E. & Buswell, A. M. Water Softening: Sign of Charge on Colloidal Particles of Hydrous Alumina, Hydrous Magnesia, and Calcium Carbonate. *Ind. Eng. Chem.*, **32**:132 (1940).
5. Corsaro, Gerald, et al. Mechanism of Polyphosphate Threshold Action. *Jour. AWWA*, **48**:683 (Jun. 1956).
6. Saville, Thorndike. The Nature of Organic Color in Water. *J. NEWWA*, **31**:79 (1917).
7. Behrman, A. S.; Kean, R. H.; & Gustafson, H. Water Purification for Color Removal. Part 1. *Paper Trade J.*, **92**: (Feb. 19, 1931).
8. Shapiro, Joseph. Chemical and Biological Studies on the Yellow Organic Acids of Lake Waters. *Limnol. Oceanography*, **2**:161 (1957).
9. Black, A. P., et al. Effectiveness of Polyelectrolyte Coagulant Aids in Turbidity Removal. *Jour. AWWA*, **51**:247 (Feb. 1959).

Stabilization of Magnesium Hydroxide in the Solids-Contact Process

Thurston E. Larson, Russell W. Lane, and Chester H. Neff

A paper presented on Jul. 13, 1959, at the Annual Conference, San Francisco, Calif., by Thurston E. Larson, Head, Chem. Sec.; Russell W. Lane, Chemist; and Chester H. Neff, Asst. Chemist; all of the State Water Survey Div., Urbana, Ill.

IN any industry, a quality product and efficient service are the keys to producing satisfied customers. Everyone is aware of the annoyance caused by a red water or a staining water, especially when obtained from a new water plant designed to soften the water and provide a quality product for which the customer is ready and willing to pay.

When a plant produces a water that still plugs hot-water lines, or scales hot-water tanks, or even causes excessive pressure losses or corrosion in transmission from plant to the household tap, the consumer has a perfect right to be unhappy and to think seriously before docilely accepting a needed increase in water rates.

Figure 1 shows some of the results of improperly softened water. The scale in each pipe was found to be composed of magnesium hydroxide, usually with some calcium carbonate and silica. In a number of places, so much scale formed on hot-water tank heating coils within a few weeks that it was impossible to provide the desired temperature.

The causes of this phenomenon were shown by the author in 1951 (*1*) and data were provided indicating the maximum pH and magnesium concentrations that would prevent magnesium scale problems.

Magnesium Solubility

Magnesium solubility is highly sensitive to pH and temperature. Based on the solubility product constant of Travers and Nouvel (*2*) the influence of temperature on the solubility of magnesium in a water of 50 ppm alkalinity is shown in Fig. 2. Changes in temperature affect the equilibrium constants, K_w and K_2, as well as $K_{Mg(OH)_2}$. Very few investigators agree on the solubility product for magnesium hydroxide, but the data selected were in the range of the various determinations near 25°C and were also the only data that indicated the determination of $K_{Mg(OH)_2}$ over a range of temperature.

The sensitivity of magnesium solubility to pH and to temperature is shown in Fig. 2. Particular attention is directed to the 32°–77°F range, which indicates that for precipitation a higher pH is needed with cold water than with warm water. The sensitivity of pH to temperature is also indicated. The effect of carbonate alkalinity is not shown. If the total alkalinity were 25 ppm, the pH at 167°F would be 0.14 lower; with a total alkalinity of 100 ppm, the pH

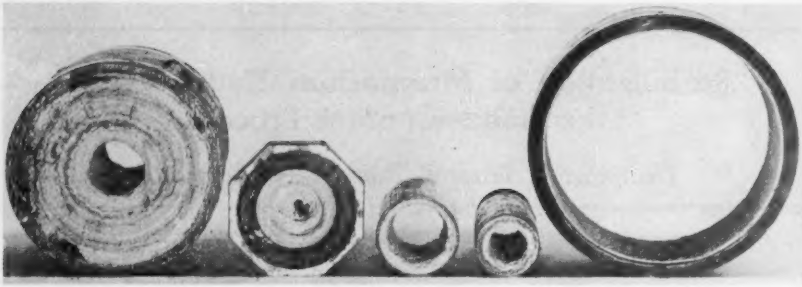

Fig. 1. Results of Improperly Softened Water

The pipe specimens shown above are (left to right): hot-water line after 35 years in a state hospital; hot-water line in a hotel; hot-water line in a city hospital; hot-water line in a state hospital; cold-water main in a city distribution system (the Hazen-Williams coefficient was reduced from 125 to 100).

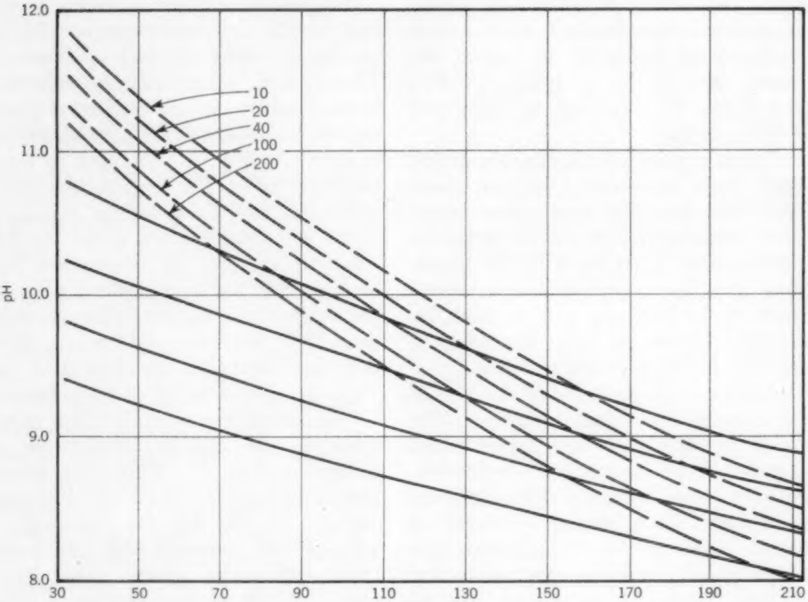

Fig. 2. Influence of Temperature on Magnesium Solubility

The dashed curves represent magnesium solubility (as $CaCO_3$) and the solid curves represent pH variation. The solubility curves are based on the solubility product constants of Travers and Nouvel (1).

at 167°F would be 0.16 pH units higher (*3*).

Figure 2 also does not show the effect of dissolved minerals on the solubility of magnesium. The data shown are for water with 200 ppm total dissolved minerals. According to the data of Naesaenen (*4*), the solubility would be increased by about 30 per cent if the total mineral content were 600 ppm. It should be recognized that, because controlled laboratory conditions do not prevail in plant operation, a degree of discrepancy between theory and practice must be expected.

Figure 3, based on field data collected in 1951, indicates *recommended* maximum pH and magnesium concentrations for treated water. The data on which these recommendations are based (*1*) were obtained from plants where magnesium hydroxide problems were experienced in hot-water tanks and hot-water lines as well as from plants where no problems occurred. As a general rule, a plant effluent at 75°F should have a pH of less than 9.0 and a magnesium hardness of less than 40 ppm; for the same magnesium hardness in cold water, a pH of 9.5 may be permissible; a 55°F well water may have a pH of 9.2. These limits are 0.5–0.7 pH units lower than predicted by theory, because the actual operating temperature of a hot-water tank is always considerably lower than at the heating surface, and because these data were obtained from waters containing less than 200 ppm dissolved minerals.

For those who prefer to use an equation to provide a numerical index to possible magnesium hydroxide problems, the following equation may be used for waters of approximately 50 ppm alkalinity and 200 ppm dissolved solids:

$$I = 2\ \mathrm{pH} + \log \mathrm{Mg} + 0.02\ t - 21.2$$

in which I is the magnesium index and t is the temperature (in degrees Fahrenheit) of the effluent. Magnesium is expressed as parts per million $CaCO_3$. When the index is such that $I \leqslant 0$, no magnesium hydroxide scale problems are likely; if I is 0.1–0.3 there may be isolated problems over long operation; 0.4–0.7 indicates that a significant number of difficulties are likely; if $I \geqslant 0.7$, problems will almost certainly be numerous after several months of continuous operation, their number and severity depending, of course, on the temperature of the heating surface and the quantities of water used.

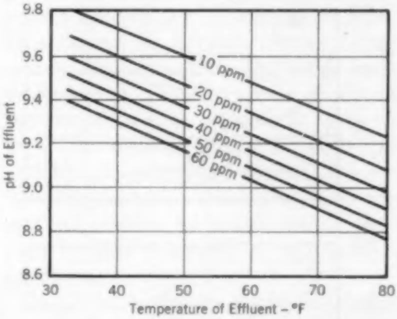

Fig. 3. Maximum Recommended Magnesium Hardness at Various Recorded Temperatures and pH Values

Hardness concentrations are expressed as $CaCO_3$.

Quality Product

There is a need to set some standard for water quality. The usual objective in public water supplies is to reduce hardness to 75–100 ppm. This has been fairly standard practice for many years. Were it not for red-water problems, water could be softened to zero hardness; in fact, that is done at a few ion-exchange plants

but the practice is limited to certain noncorrosive waters.

It has long been recognized that the maintenance of calcium carbonate stability is the most effective method for preventing red water; the effectiveness is enhanced if the maximum possible calcium concentration is maintained (*12*). It has also been shown (*1*) that an alkalinity of less than 50 ppm results in a decrease in the saturation index at hot-water tank temperature.

It has also been long established (*5*) that in waters with a pH greater than 9.5 there is a greater tendency to dissolve zinc from galvanized pipe or hot-water tanks. This tendency is also decreased when calcium carbonate stability is maintained because the formation of a protective zinc carbonate coating is dependent on the same factors as govern calcium carbonate stability.

The hazards of excessive magnesium were recognized as long ago as 1919 by Sperry (*6*) and again by Hoover in 1942 (*7*). Lime softening plants should therefore regulate their treatment process to provide an alkalinity near a minimum of 500 ppm, a calcium hardness of at least 50 ppm, and a magnesium concentration of not more than 40 ppm; pH should be adjusted to a satisfactory level above the saturation pH of the water at the temperature of the plant effluent. Thus, a saturation pH of 8.5 is necessary for a 77°F plant effluent, and a pH of 9.0 is needed for a 33°F effluent. These limits may be considered arbitrary, but they are designed to insure the quality of the product delivered to the consumer's tap.

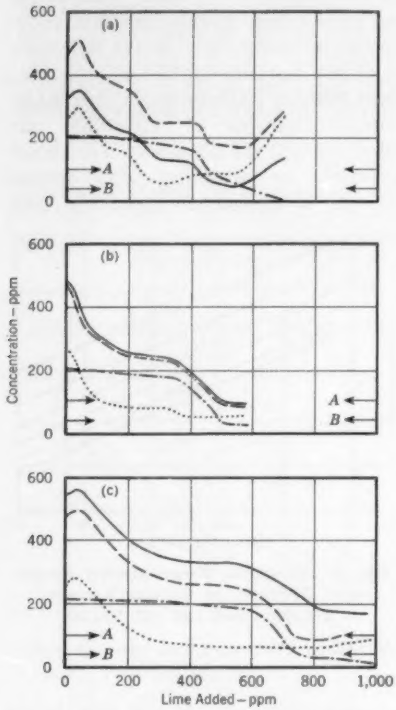

Fig. 4. Reduction of Magnesium Hardness Under Various Conditions of Alkalinity and Total Hardness

Solid, dashed, dashed and dotted, and dotted curves represent alkalinity, total hardness, magnesium hardness, and calcium hardness, respectively. Parts a, b, and c represent the following conditions: Part a—total hardness exceeds alkalinity; Part b—total hardness and alkalinity are equal; Part c—alkalinity exceeds total hardness. Levels A and B represent desired total-hardness and magnesium hardness levels, respectively. All concentrations are expressed as $CaCO_3$.

Chemistry of Softening

The earliest method used to soften water consisted of adding hydrated lime to react with calcium bicarbonate to form insoluble calcium carbonate. This reaction is stoichiometric at equilibrium conditions and limited only by the solubility constant for calcium carbonate.

The reaction described above, however, is only one of at least a dozen or so interrelated reactions that occur simultaneously when hydrated lime is added to a hard water containing calcium, magnesium, and carbonate alkalinity. The reactions proceed to a point of equilibrium, which is dependent on time, the proportions of natural components, and the amount of added lime. The reactions are predictable if time and aids to the approach to equilibrium are permitted.

Perhaps the simplest way to learn what will result from the addition of lime to a given water is to set up a series of ten, fifteen, or twenty 1-qt or 1-gal bottles. With the temperature maintained at that of the plant water, the operator can add increasing quantities of lime to the bottles, shake them well periodically, allow them to stand overnight, and then perform analyses of the clear supernatants for hardness, calcium, alkalinity, and pH.

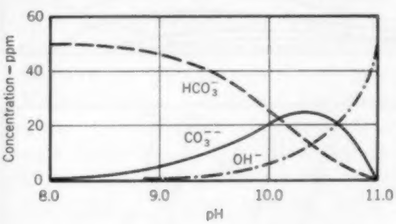

Fig. 5. Proportions of Various Forms of Alkalinity at pH 8.0–11.0 and Total Alkalinity of 50 ppm

Concentrations are expressed as $CaCO_3$.

The results of such tests will depend on the relative proportions of alkalinity to hardness of the raw water. This is illustrated diagrammatically in Fig. 4. The numerical values in Fig. 4 are roughly representative of room temperature reaction after 6 hr. From the upper illustration, it can be seen that the hardness could not be reduced to the desired level without the aid of soda ash. With the addition of soda ash (middle illustration), an alkalinity equal to the hardness was obtained, and little difficulty was experienced. With the third type of water (lower illustration), it can be seen that the excess bicarbonate alkalinity required the use of more lime. It will be noted that the addition of lime reduces the calcium hardness first, before any appreciable amount of magnesium is removed; and until this point is reached the alkalinity and calcium curves are parallel. Addition of more lime causes the calcium content to increase or decrease with magnesium precipitation. Under either condition the magnesium is eventually reduced to a low concentration. In each example, a longer reaction time or contact with a slurry of calcium carbonate and magnesium hydroxide would provide a clear approach to equilibrium conditions.

In Fig. 5 the proportions of the various forms of alkalinity are shown for the pH range of 8.0–11.0 with an alkalinity of 50 ppm.

In Fig. 6 the calculated solubility limits are shown for various pH values and alkalinity concentrations. The much lower theoretical values indicate that equilibrium conditions had not been attained in the jar tests in the previous figure. Hartung (*8*) and Calise (9) recently showed the benefits of using slurry circulation to approach the equilibrium conditions.

At the equilibrium obtained thereby, however, a dilemma exists: although saturation with respect to magnesium hydroxide is not desirable, saturation with respect to calcium carbonate is. If magnesium saturation were corrected by reducing the pH, calcium carbonate saturation would be de-

stroyed, unless excess calcium hydroxide were present.

In usual practice, equilibrium conditions are rarely obtained even under optimum conditions of contact time and slurry circulation. Supersaturation may, however, be a blessing in disguise, because it provides greater flexibility in control. As previously shown, the pH must be reduced to avoid precipitation of magnesium hydroxide; supersaturation permits pH adjustment to a point where calcium carbonate saturation can be attained without the use of excessive amounts of calcium hydroxide.

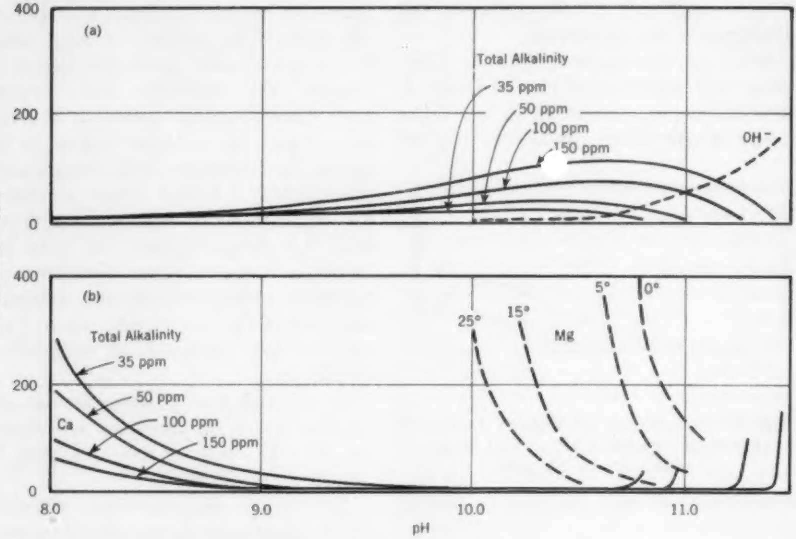

Fig. 6. Calculated Solubility Limits at Various pH Values and Alkalinity Concentrations

Part a shows relative concentrations of CO_3^{--} and OH^-; Part b shows Ca solubility at various concentrations of alkalinity at 15°C, and Mg solubility at 0°, 5°, 15°, and 25°C (total dissolved minerals, 200 ppm). Concentrations are expressed as $CaCO_3$.

Control Tests

When lime-soda softening was first introduced, there were no simple titration procedures for separate determination of calcium and magnesium hardness. Also, the possible problems with magnesium hydroxide were not fully recognized. The only control tests were for total hardness (H), phenolphthalein (P) and methyl orange (M) tests for alkalinity. Such tests sufficed as long as the only criterion of a satisfactory product was the total hardness of the effluent. This is no longer true, however. The inadequacies of P, M, and H control are insufficient magnesium removal, excessive use of lime, and consequent excessive demands on recarbonation.

The P and M determinations must be made with great care if they are used to indicate hydroxyl ion concentrations (for lime dosage). The cor-

rections associated with temperature and total mineral content, as indicated by Dye (*10*), should also be applied.

With the advent of the EDTA procedure for calcium hardness and total hardness, the old control criteria became outmoded. For 10 years, quick, simple titration procedures have been available for the separate determination of calcium, and for magnesium by difference from the total hardness. There is, therefore, no reason to retain the outdated *P*, *M*, and *H* control tests when a quality product is desired.

It is a logical step to base lime dosage on the residual magnesium hardness, the second step in the softening chemistry, as even an accurate $(2P - M)$ determination is only an indirect indication, by means of the hydroxyl-ion concentration, of possible magnesium hardness. The magnesium determination, however, is a direct indication of the quality of the end product, regardless of the plant temperature, because calcium reduction is insured by prescribed adjustment of the lime dosage and by precalculation of the soda ash requirement.

Magnesium hardness is the difference between the total hardness and the calcium hardness. With practice, an analyst can determine calcium hardness on the same sample used for the alkalinity determination. After the usual *P* and *M* alkalinity titrations, the calcium hardness buffer solution and indicator are added and titration is continued with EDTA. The pink color associated with phenolphthalein is observed to change rather suddenly to a wine color at the calcium endpoint.

Recarbonation

With proper magnesium hardness in the effluent, recarbonation is necessary to reduce the pH to the level of calcium carbonate stability.

At one 1.5-mgd solids-contact plant, 40 ppm carbon dioxide is required to reduce the pH of the treated water to 8.5–9.0. The fuel oil (No. 2) used costs $2.34 for 1 mil gal of water. Another plant of 0.4-mgd capacity requires similar carbon dioxide treatment. Propane provides carbon dioxide at a cost of $4.30 for 1 mil gal. Much less maintenance has been required for the propane equipment than for fuel oil equipment. For 40 ppm carbon dioxide, the equivalent cost of alum for this purpose would be $18.25 for 1 mil gal.

If, on the other hand, alum is added with lime and soda ash, it must be neutralized with additional lime and soda ash to maintain the alkalinity desired in the end product and the pH necessary for magnesium precipitation. The effectiveness of alum for magnesium removal appears to be limited at higher temperatures (70°–80°F) but more effective at lower temperatures (35°–50°F). The difficulty of reducing magnesium hardness to its calculated solubility is indicated by the recorded use of alum dosages of 50–85 ppm during winter months and 17–35 ppm during the summer months. Such use of alum *does not* eliminate the need for recarbonation.

It has been indicated that soda ash is required in waters with excessive noncarbonate hardness to precipitate calcium and provide sufficient residual alkalinity for calcium carbonate stability. The usual quantity required may be calculated from the total hardness and alkalinity of the raw water.

$$H - M - (25 \text{ to } 50) = \text{ppm } Na_2CO_3 \text{ (as } CaCO_3\text{)}$$

This dosage is designed for an effluent alkalinity of 50 ppm and a hardness of 75–100 ppm; it may be desirable to add a portion of it after filtration if

excessive lime buildup on the sand filters indicates a need for recarbonation to a subsaturation pH.

Lime dosage may be determined by the following method of calculation:

$$2.3\ CO_2 + \text{Alkalinity} + \text{Mg} + \text{excess} = \text{ppm CaO (as } CaCO_3)$$

Control tests for magnesium will show a need for more lime if the magnesium hardness is greater than 40 ppm or for less lime if it is less than 20 ppm.

An additional control test concerns the circulation of the slurry. In the plants used for this study, it was not possible to maintain as high slurry concentrations in the draft tubes as were obtained by Hartung (*11*). Because solids-contact units are designed ostensibly to take advantage of the clarifying effects of suspended solids, however, every effort should be made to maintain the maximum possible slurry concentration without excessive carryover to the filters. The permissible concentration was found to be different for each plant, and inconsistencies in the methods for determining suspended solids caused further complications.

On the basis of a limited number of gravimetric determinations, little or no consistent relation involving specific gravity or sludge volume was found for 5-min settling periods at three plants. It would thus appear that each plant must experimentally determine empirical limits of suspended solids for optimum operation. It is probable that the quantity and type of turbidity in the raw water, temperature, and hardness may be variables that seriously limit the effectiveness of any general rules for suspended solids.

The frequently unrecognized problems caused by magnesium hydroxide can be overcome in lime softening by proper control tests and recognition of the dependence of magnesium hydroxide solubility on pH and temperature. In order to maintain a defined desirable quality for softening plant effluent, the use of the magnesium determination as a control test is recommended.

References

1. Larson, T. E. The Ideal Lime-Softened Water. *Jour. AWWA,* **43**:649 (Aug. 1951).
2. Travers, A. & Nouvel. On the Solubility of Magnesium Hydroxide at High Temperatures. *Compt. Rend.* (Fr.), **188**:499 (1929).
3. Langelier, W. F. Effect of Temperature on the pH of Natural Waters. *Jour. AWWA,* **38**:179 (Feb. 1946).
4. Naesaenen, R. The Potentiometric Determination of the Solubility Product of Magnesium Hydroxide. *Z. physik. Chem.* (Ger.), **188A**:272 (1941).
5. Britton, S. C. Resistence of Galvanized Iron to Corrosion by Domestic Water Supplies. *J. Soc. Chem. Ind.,* **55**:19T (1936).
6. Sperry, W. A. The Lime Softening of Water and the Use of Sludges as an Aid Thereto. *Jour. AWWA,* **6**:215 (Mar. 1919).
7. Hoover, C. P. Stabilization of Lime-Softened Water. *Jour. AWWA,* **34**:1425 (Sep. 1942).
8. Hartung, H. O. Calcium Carbonate Stabilization of Lime Softened Water. *Jour. AWWA,* **48**:1523 (Dec. 1956).
9. Calise, V. J.; Duff, J.; & Dvorin, R. Chemical Reactions in Hot and Cold Treatment Units. *Jour. AWWA,* **47**:665 (Jul. 1955).
10. Dye, J. F. Correlation of the Two Principal Methods of Calculating the Three Kinds of Alkalinity. *Jour. AWWA,* **50**:800 (Jun. 1958).
11. Hartung, H. O. Treatment Plant Innovations in St. Louis County, Missouri. *Jour. AWWA,* **50**:965 (Jul. 1958).
12. Ryznar, J. W. A New Index for Determining Amount of Calcium Carbonate Scale Formed by a Water. *Jour. AWWA,* **36**:472 (Apr. 1944).

Advantages of Ground Level Distribution Storage

Marsden C. Smith

A paper presented on Jul. 16, 1959, at the Annual Conference, San Francisco, Calif., by Marsden C. Smith, Chief Water Engr. (retired), Dept. of Public Utilities, Richmond, Va.

IN the early days, when most cities were compactly built and their streets had little or no paving, water utilities found it both simple and economical to eliminate zones of low water pressure by enlarging the mains supplying the zones. The spreading out of industrial, commercial and residential properties, improved transportation, and many other factors have caused a gigantic increase in the cost of new supply mains. At the same time, new uses of water, most of which are seasonal, have greatly increased the necessity for added facilities to maintain water pressure.

Usually, the most practical way to satisfy higher demands in areas remote from the supply is to store water during hours of low demand and draw from storage during the hours of heaviest use. By this means the fullest use of the capacity of the supply mains can be made and many operating costs can be materially reduced.

When distribution storage was first used, the choice of types was limited to standpipes or elevated tanks. Ground level storage usually requires pumping when water is being drawn from storage. Early pumping facilities were expensive to construct, maintain, and operate. Central-station electric power, standby power, centrifugal pumps, and automatic controls were either unavailable or unreliable. Today these limitations no longer exist.

The purpose of this discussion is to direct attention to the many advantages of ground level storage over elevated storage for the relief of low water pressure, especially in residential areas. It is not, however, intended to suggest that elevated storage should never be used, for such a proposal would be ridiculous; rather it is intended to emphasize the often unrecognized benefits of ground level distribution storage. It must, however, be understood that an efficient and reliable automatic control is necessary for ground level storage if the costs of pump operation are not to be too expensive to compete with elevated storage.

The term, "service zone," as it is used in the following, means a part of a water supply system which sometimes is dependent upon either elevated or ground level storage (with pumps) for the maintenance of water pressure. Obviously, there may be one or more such zones in any given distribution system, all served by the same supply pumps.

Public Relations

No business—least of all a municipal corporation—can afford to disregard the wishes of the public. The strenuous objections to the construction of almost any design of elevated tank in residential and other areas are too universal to require elaboration. Injunc-

tions frequently force the use of ground level storage and often the height of a reservoir is limited to that which may be screened by trees and other foliage. Thus, ground level and underground storage are generally more desirable from the all-important standpoint of public relations.

Flexibility

In order for an elevated tank to function effectively, the lowest normal water level in the tank must be high enough to maintain pressures at the extreme limits of the service zone, even during periods of peak demand. Unfortunately, when the zone demand is greatest the water level in a tank is usually at its lowest. What is worse, the pressure loss in the distribution system of a tank zone varies approximately as the square of the demand. Limitations on the height of an elevated tank necessarily limit the choice of its location to the highest ground within its service zone. The highest ground level is often quite remote from the most desirable location from all other points of view. Thus ground level storage, which may be located wherever desired, permits a much greater choice of locations.

Ground level storage also permits greater flexibility in design and in the selection of construction materials. Obviously, earth or gravity walls cannot be used for elevated tanks, and even prestressed concrete has had only limited application in this field. Consequently, steel is almost the only practical available material.

Elevated storage also limits the quantity of storage that may be used. Steel elevated tanks of more than 2-mil gal capacity are rare, and tanks that store more than 3 mil gal appear to be impractical. On the other hand, there is no limit to the size of ground level storage.

Elevated storage, once built, absolutely fixes the pressure available in the system zone to that produced by the elevations of the water in the tank. No practical means has yet been devised to vary the height of an elevated tank after construction. Hence there can be no flexibility in the pressures maintained, either in the tank service zone or in the overall distribution system.

The fact that the height of the tank fixes pressure so that it cannot be changed, no matter how necessary a change may be, is the greatest disadvantage of elevated storage. Ground level storage, on the other hand, permits complete flexibility in maintained pressures because they can be regulated as closely as desired. Hourly and seasonal pressure variations are secured by the automatic control of pump speeds and by adjustable back-pressure valves during the time the pumps are not needed. Any desired change in the range of pressures can be had at a small cost, if ever needed, by a change of pump impellers or even by changing the pump. Inflexibility in water pressures, which must inevitably result when elevated storage is used, seriously increases operating costs, increases the problems of operation, and lessens the reliability of service in the entire service zone.

Hence it seems that from the standpoints of public relations and operational flexibility there can be no doubt of the great advantages of ground level storage. The unlimited quantity that may be stored, the freedom in the selection of construction materials, the greater choice of locations that will result in the greatest operating efficiency, and, most important, the abil-

ity to adjust system pressures as needed for maximum economy, all are good arguments for the use of ground level storage in most instances.

Economy

Greater flexibility in the selection of the tank location within the storage zone and the much greater choice in the size, design, and materials used, generally result in a lower first cost.

It may be helpful to examine the actual operation of one zone of the Richmond, Va., water system and estimate what operation would cost were the system provided with ground rather than elevated storage. In this way, a sufficiently accurate cost comparison may be obtained for at least one zone of one system. To make such a cost comparison it is necessary to use the best available data, and reference will therefore be made to other actual zones of the Richmond system.

The zone selected indicates a cost reduction more favorable to ground level storage than will always exist. This is because of the great use of water in the area of which this zone is a part. On the other hand, the ground levels in the zone and in the area selected are such that they materially lessen the savings in the cost of pumping.

The zone in question is served by a 1-mil gal elevated tank, its bottom elevation being 300 ft and its overflow 325 ft. The point of maximum ground elevation (225 ft) in the area is quite near the area supply pumps; and the maximum ground elevation in the zone, which is quite level, is at the tank site and is 200 ft. Had ground level storage been used, it probably would have been placed at the same location with its overflow at an elevation of 240 ft and its bottom elevation at 200 ft. Thus, the ground storage tank when full would have been 60 ft lower than is the bottom level of the elevated tank.

First Cost

The elevated tank was built in 1945, which was before suitable automatic controls were available, at a cost of \$131,232 exclusive of land. It has been estimated that it would have cost \$180,000 to build the tank in 1957. In 1957 a 1-mil gal ground level reservoir, with pumps, automatic controls, piping, back-pressure valves, and a handsome colonial type brick building, was constructed to form a new zone for a total cost of \$109,200 exclusive of land. Hence the initial cost of ground level storage would have been \$70,800 less than the same capacity in elevated storage in 1957.

But this is not all. The building, pumps, and controls included in the \$109,200 were designed for a much greater ultimate capacity. Already a second ground level reservoir of 1.4-mil gal capacity has been found necessary and is being constructed for \$66,356. This means that with the development not yet completed the total investment is already at least \$256,000 less than would be necessary for elevated storage—quite a worthwhile saving.

Maintenance Costs

The maintenance of elevated storage tanks is more expensive even when the same material is used for construction. Painting an elevated steel tank is an expensive job, requiring, as it does, fearless, specially trained mechanics. One reliable steel-tank maintenance firm estimates the cost of cleaning and painting steel elevated tanks to be at least twice the cost of steel ground

level tanks of the same capacity. That estimate, moreover, is based on using the same skilled mechanics, which is not at all necessary for ground level tanks.

If cleaning and painting are assumed to be necessary every 4–5 years, from actual contract prices it can be shown that the cost of painting is approximately $800 more per year for an elevated tank of 1-mil gal capacity than for a ground level tank of the same size.

Cathodic protection also costs about twice as much for an elevated steel tank as for the same size of ground tank. For a 1-mil gal tank, cathodic protection is approximately $250 more per year for elevated than for ground level storage. This cost difference is also estimated from actual contracts.

Unfortunately, the system of accounting at Richmond does not permit an accurate separation of the cost of servicing the several automatic pumping stations in the system. Station charts are changed once each week, and this is practically the only regular maintenance cost. The buildings are brick with slate roofs and, as there are no windows, painting is needed only for trim, either inside or out. It is believed that $1,000 per year is a liberal allowance for the maintenance and supervision of each station.

Both the elevated and the ground level tanks and pumps are equally maintained and any difference in obsolescence is probably less for the ground level installations. Hence depreciation and obsolescence are applied only to the initial cost difference of the two systems.

Operation Costs

As has been said the actual cost of pumping with elevated storage can be determined exactly, but obviously what the pumping costs with ground level storage would be can be only an approximation.

An elevated tank must be high enough to maintain pressures sufficient for the maximum demand even though it occurs for only a few hours each year. This means that during all other hours—in winter and even at midnight—the system supply pumps must produce pressures that are not needed except for the relatively few peak hours of each year. It is this unnecessary pumping head that causes the power required for elevated storage almost always to exceed greatly that required for pumping to and from ground storage.

TABLE 1

*Estimated Minimum Annual Savings of Ground Level Storage Over Elevated Storage**

Item	Saving $/yr
Fixed charges (at 8 per cent of minimum first-cost difference)	5,660
Tank painting	800
Cathodic protection	250
System and zone pumping	12,560
Total	19,270
Maintenance, supervision, and pumping from ground level level storage	−1,310
Adjusted total	17,960

* Both tanks are assumed to be made of steel; all figures are for 1-mil gal capacity.

On a typical summer day, the pumps supplying the Richmond distribution system were required to pump 36.87 mil gal at an average of 42 ft more head than would have been required had ground storage been used. The system demand is obviously not that great during most of the year, how-

ever, and actual demand records provide a better estimate.

During the study a mass of data was collected on hourly station pumping rates, total lift, elevated-tank levels, estimated hourly zone demand, actual elevated tank "in and out" quantities, successful zone pressures, and friction losses. These data, together with estimates for ground storage, have been combined to determine as closely as possible the excess in system and zone pumping costs that can be attributed to the use of elevated instead of ground level storage.

It should be noted that it is usually an advantage to fill ground level storage by a separate main directly from the supply or from the dividing line between the zone and area supply pumps. This is because both the amount pumped out of the tank and the supply system pressures may thereby be considerably lessened.

According to highly conservative estimates, the total zone and supply pumping cost for 1958 was $8,300 more with elevated storage than it would have been had ground level storage with pumps been used. An estimate based on the average of recent years places the amount at $12,560. If the annual demand should become equal to the maximum day, this increase in pumping power costs with elevated rather than ground level storage would be $24,000 per annum. Thus the increase in the cost of pumping caused by elevated storage constantly increases as the area and zone demands increase.

As the maximum elevation in the zone supplied by the elevated tank is 24 ft less than the elevation close to the area supply pumps, the pumps at the zone storage would be needed only during the hours of heavy demand. The amount of pumping that would have been necessary from ground storage has been estimated from the actual elevated-tank water levels and the area supply pumping pressures averaged for recent years. The cost was approximately $310. This cost was difficult to determine, but it is believed to be reasonably accurate.

Overall Savings

Minimum annual savings of 1 mil gal ground storage over elevated storage are given in Table 1. It is no doubt surprising to the reader that the pumping cost is so much less with ground storage, because one would think that letting the water down to ground and pumping it back up again would be wasteful. The explanation is simple, however: to keep an elevated tank reasonably full, all water used in the distribution system must be pumped to greater height than is necessary during periods of normal use.

The reduction in operating costs that can result from the use of ground level distribution storage instead of the conventional elevated tank, is determined by several factors. Some of these are: [1] the quantity of storage required, [2] the total amount and rate of withdrawal of water from storage, [3] the relation between the amount of water used in the zone and in the overall system, [4] the relation between elevation in the zone and in the overall system, and [5] the probability of increases in water use in and beyond the zone storage.

The example used in this article is believed to be typical when considered in the light of these factors and the savings in operating costs show why all tanks built in Richmond since 1946 were built at ground level and used automatically controlled pumps.

Reliability

Central-station power, needed for the operation of pumps with ground level storage, has today reached a high degree of reliability. Automatic centrifugal pumps driven by central station power are now serving some of our largest water distribution systems with complete success. Ground level storage can usually be so placed that adequate pressures can be maintained for fire engines and partial commercial service in the rare event of a power failure.

The reliability of modern automatic control is amazing; at Richmond, automatic control has caused only one pumping failure in 14 years. During the same period in one other station, operated by highly skilled personnel, human errors have caused four pumping failures, one of which hospitalized and nearly cost the life of the operator and resulted in highly expensive damage to the station equipment.

Some utilities consider it advisable to supplement ground level storage with a small standby elevated tank which is kept full for a short power failure. Because the size of such a tank would be but a small fraction of that required if all storage were elevated, the cost of the elevated tank and of the power for pumping would not be excessive. This is not a recommendation; it is mentioned for consideration only.

Much higher pressures must be maintained while elevated storage is being filled than is necessary for filling the same capacity of ground level storage. Greater pressure obviously increases the danger of main breaks everywhere in the area supplied by the system pumps. A broken main is a serious health and fire hazard, and any unnecessary increase in pressure certainly reduces the reliability of the system as a whole.

It is often argued that elevated storage is always available for an emergency. This is unfortunately not always so. In systems with zone storage, at the very time the tank should be full because the system demand is at its maximum, the pressure loss between the supply pumps and the tank is also at its maximum. Thus the tank either may be empty or have only a minimum quantity in reserve at the very time when it should be full. This often happens because the level in the tank gradually drops during the morning and early afternoon, even when the supply pressure is actually greater than necessary.

If ground storage is placed at the same site as elevated storage, the level of ground storage when full is usually 50–75 ft below the level in the elevated tank when the latter has just become empty. The difference is 60 ft in the zone of the Richmond system under consideration. This 60 ft has been of tremendous importance during periods of heavy demand. Obviously any portion of the 60 ft can be used to increase greatly the rate of filling of the zone storage; this is done by setting the back-pressure inlet valve to the ground storage to reduce zone pressure during hours when higher pressures are not needed. By a slight reduction in zone pressure during the morning and early afternoon hours, ground storage can be kept almost full when the hours of peak demand arrive.

What may often be of even greater importance, the ability to vary the zone pressures permits a material increase in the effective capacity of the

mains between the system supply pumps and the zone storage and thus postpones or eliminates the expense of enlarging the mains.

With elevated storage, however, zone pressures are fixed by the water level in the tank. To overcome the problem of the level's repeatedly becoming dangerously low, there are three possible remedies:

1. The capacity of the elevated storage may be enlarged with an additional elevated tank. That would cost at least $180,000, however, and would materially increase the maintenance and fixed charges for each year.

2. The pressures at the area supply pumping station may be increased by rebuilding of the pumps. That would make it necessary to raise the pressure proportionally as the square of the quantity being delivered; obviously, there is a limit to such an increase.

3. The mains between the system supply pumps and the zone storage may be enlarged. In the zone considered in this article, enlargement would cost at least $320,000. This surely is an expense that should be postponed as long as possible.

These undesirable and expensive alternatives are frequently the reason why the water level in so many elevated tanks is allowed to fall to dangerously low levels just at the very moment when the maximum reserve is needed. It is always hard to spend much money for benefits received only during the relatively few hours of peak demand. Thus it seems that even from the standpoint of reliability, ground level storage is frequently much more effective than elevated storage.

Conclusion

From the foregoing it should be abundantly clear that its fixed height is an extremely serious inherent fault of elevated distribution storage. Either the tank is too high for normal demands or too low to provide adequate pressures during the hours of maximum use. One reputable engineering consultant recommended that the elevated tank considered in this article be 40 ft higher than was considered proper by another equally reputable consultant. Surely both could not be right, and the tank legs could not be varied once the choice between the recommendations was made. The tank was built at the lower of the two levels, but severe operating problems have nonetheless resulted from efforts to prevent the tank from becoming empty on days of heavy demand.

There can be no question that, from the standpoint of reliability, improved public relations, choice of location, materials, size, and both initial and operating costs, ground level storage with automatically operated pumps is preferable to elevated storage. Elevated storage often can no longer be justified except in small or unusual public water systems.

Although it is not the author's intent to propose that all elevated storage be abandoned, it is hoped that the foregoing discussion will encourage a more complete investigation of the benefits that can result from the use of ground storage in distribution systems.

79th Annual Conference
Civic Auditorium, San Francisco, Calif.
July 12–17, 1959

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1959 CONFERENCE STATISTICS

San Francisco Registration by Days

	Men	Ladies	Total
Preregistration	708	252	960
Sunday, Jul. 12	669	308	977
Monday, Jul. 13	710	198	908
Tuesday, Jul. 14	198	27	225
Wednesday, Jul. 15	79	—	79
Thursday, Jul. 16	62	—	62
TOTALS	**2,426**	**785**	**3,211**

Geographic Distribution of Registrants

UNITED STATES

Alabama	30
Alaska	3
Arizona	34
Arkansas	14
California	1,269
Colorado	43
Connecticut	18
Delaware	2
Dist. Columbia	17
Florida	29
Georgia	33
Hawaii	11
Idaho	11
Illinois	173
Indiana	71
Iowa	61
Kansas	53
Kentucky	18
Louisiana	10
Maine	3
Maryland	17
Massachusetts	30
Michigan	47
Minnesota	30
Mississippi	10
Missouri	69
Montana	8
Nebraska	8
Nevada	8
New Hampshire	2
New Jersey	115
New Mexico	12
New York	215
North Carolina	15
North Dakota	2
Ohio	102
Oklahoma	8
Oregon	58
Pennsylvania	181
Puerto Rico	5
Rhode Island	13
South Carolina	14
South Dakota	3
Tennessee	22
Texas	87
Utah	33
Virginia	11
Washington	70
West Virginia	5
Wisconsin	39
Wyoming	3

CANADA

Alberta	1
Brit. Columbia	7
Manitoba	2
Ontario	48
Saskatchewan	3

FOREIGN

Asia	2
Latin America	3
TOTAL	**3,211**

Comparative Registration Totals—1950–1959

Year	Place	Men	Ladies	Total
1959	San Francisco	2,426	785	3,211
1958	Dallas	2,337	687	3,024
1957	Atlantic City	2,398	669	3,067
1956	St. Louis	2,026	510	2,536
1955	Chicago	2,075	512	2,587
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007

Win, Place & Show in Section Awards

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Pacific Northwest	**75.0%**	**California**	**37.37**	**California**	**1,583**
Intermountain	71.1%	Arizona	33.60	Southwest	1,060
California	63.8%	Florida	28.42	New York	882

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Association Awards

Honorary Membership was conferred upon Frank C. Amsbary Jr., E. Sherman Chase, Morris S. Jones, and Marsden C. Smith. The citations follow:

Frank Clifford Amsbary Jr., Vice-President and General Manager, Long Island Water Corp., Lynbrook, N.Y.: *Member of the Association since 1927; Life Member 1957; President 1956; Director 1939–42; Illinois Section Chairman 1934; Fuller Award 1941; a gentleman who combines courtesy with a high degree of executive competence, bringing great credit to the industry; one to whom the distinction of honorary membership brings evidence of well deserved appreciation.*

Edward Sherman Chase, Partner, Metcalf & Eddy, Boston, Mass.: *Member of the Association since 1919; Life Member 1949; Director 1944–47, 1956–59; Fuller Award 1949; thoroughly devoted to Association activities and to the advancement of his fellow engineers; a living symbol of the modern New England spirit, who particularly merits the distinction of honorary membership because of his long years of voluntary service in the fields of water supply and waste water control.*

Morris Shelley Jones, Retired General Manager, Water Department, Pasadena, Calif.: *Member of the Association since 1924; Life Member 1954;*

California Section Chairman 1942; Director 1951–54; Fuller Award 1955; one who brought to the administration of the Pasadena water system a high degree of intelligence and who developed within his community a highly compatible relationship between the water utility and its customers.

MARSDEN CHURCHILL SMITH, Retired Chief Engineer, Department of Public Utilities, Richmond, Va.: *Member of the Association since 1925; Life Member 1955; Director 1937–40; Fuller Award 1940; one who brought to his city's water department many of the fruits of his inventive genius; and one who brought to water supply practice many devices which represented the combination of his mechanical and electrical skills in useful components of modern water systems.*

The John M. Diven Medal, awarded to the member whose services to the water utility field during the preceding year are deemed most outstanding, was presented to Fred Merryfield. The citation follows:

FRED MERRYFIELD, Professor of Sanitary Engineering, Oregon State College, and Partner, Cornell, Howland, Hayes & Merryfield, Corvallis, Ore.: *for his outstanding and forceful leadership of the Association's ad hoc committee on public information, his continuing leadership as chairman of the Committee on Water Utility Advancement, and his energetic efforts to advance the industry and its personnel.*

The John M. Goodell Prize, granted for the best paper published in the JOURNAL from October 1957 through September 1958, was conferred upon Louis R. Howson. The citation follows:

LOUIS RICHARD HOWSON, Partner, Alvord, Burdick & Howson, Chicago, Ill.: *for his paper "Factors Affecting Long-Distance Transmission of Water," as published in the October 1957 issue of the Journal* (Vol. 49, page 1359). *The selection was made because of the background of broad experience and objective engineering judgment displayed, plus the clarity of expression of ideas, which make the paper one of great value to all persons who may study it in the future.*

Division Awards, granted for the best JOURNAL paper (October 1957–September 1958) in the field of interest of each of the four AWWA Divisions, were presented to Martin E. Flentje and Robert J. Sweitzer, Alexander C. Rener, Dwight F. Metzler et al., and Richard Hazen. The citations follow:

Distribution Division Award: MARTIN ERNEST FLENTJE, Research Engineer, American Water Works Service Co., Philadelphia, Pa., and ROBERT J. SWEITZER, Director of Research and Development, Lock Joint Pipe Co., East Orange, N.J.: *for their paper "Further Study of Solution Effects on Concrete and Cement in Pipe," published in the November 1957 issue of the Journal* (Vol. 49, page 1441). *This paper continues the record of valuable studies made by the authors and gives the reader a substantially improved understanding of the factors which adversely affect concrete.*

Management Division Award: ALEXANDER CHARLES RENER, Senior Water Works Engineer, Department of Water & Power, Los Angeles, Calif.: *for his paper "Developing a Safety Program for the First-Level Supervisor," published in the February 1958 issue of the Journal* (Vol. 50, page 281). *This paper gives support to the Association's safety program by making clearer the importance of the supervisor in establishing safety consciousness among the men who benefit most from the program.*

Purification Division Award: DWIGHT F. METZLER (Director), RUSSELL A. CULP (Chief, Water Supply Section), and HOWARD A. STOLTENBERG (Chief Chemist, Water & Sewage Laboratory), all of the State Board of Health, Topeka, Kan.; and RICHARD L. WOODWARD (Chief, Water Supply), GRAHAM WALTON (Senior Sanitary Engineer), CHARLES M. PALMER (Resident Biologist), and FRANCIS M. MIDDLETON (Scientist Director), all of the US Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio: *for their paper "Emergency Use of Reclaimed Water for Potable Supply at Chanute, Kansas," published in the August 1958 issue of the Journal* (Vol. 50, page 1021). *In this paper, the growth of demand for water and the lack of sustained yield by streams upon which cities depend are dramatized by the record of the extraordinary steps which had to be taken to provide this important Kansas community with water service during a severe drought. (Other authors of this paper were Shih Lu Chang and Norman A. Clarke, also of the Taft Sanitary Engineering Center.)*

Resources Division Award: RICHARD HAZEN, Partner, Hazen & Sawyer, Engineers, New York, N.Y.: *for his paper "Financing and Cost Allocation in Regional Water Systems," published in the September 1958 issue of the Journal* (Vol. 50, page 1136). *This paper provides a clear account of the engineering studies required to develop a regional water supply and the financial studies which are required to make the project successful. It charts a path which many cities must follow to protect their future growth.*

The Wendell R. LaDue Safety Awards, granted to utilities for outstanding accomplishment in safety during a calendar year, were presented to the Jersey Shore (Pa.) Water Co., the Monongahela Valley Water Corp. of Elizabeth, Pa., and the San Diego (Calif.) Water Dept. The citations follow:

Class 1: JERSEY SHORE (Pa.) WATER CO., E. F. Jones, President: *for a perfect 1958 safety record covering 18,118 man-hours of work by 9 employees, following a perfect record of no lost-time injuries for the preceding 9 years.*

Class 2: MONONGAHELA VALLEY WATER CORP. (Elizabeth, Pa.), Francis D. Donahue, Manager: *for a perfect 1958 safety record covering 51,876 man-hours of work by 27 employees, following a perfect record of no lost-time injuries for the preceding 9 years.*

Class 3: SAN DIEGO (Calif.) WATER DEPT., Paul Beermann, Director: *for a perfect 1958 safety record covering 767,000 man-hours of work by 383 employees, following a perfect record of no lost-time injuries in 1957.*

The Harry E. Jordan Scholarship Award, granted to further the education of deserving applicants from the Midwest (a different region is selected each year), was conferred upon John J. Grimmer, a graduate student in business administration at Marquette University, Milwaukee, Wis. [It was decided this year, rather than present the scholarship award at the Annual Conference, to establish the practice of making the formal presentation at the meeting of the section in which the recipient lives.]

The George Warren Fuller Awards were presented to 25 men whose sections had nominated them in the year beginning with the 1958 Annual Conference at Dallas and ending with the opening of the 1959 Conference at San Francisco. The awards—which are conferred for "distinguished service in the water supply field and in commemoration of the sound engineering skill, the brilliant diplomatic talent, and the constructive leadership of men in the Association which characterized the life of George Warren Fuller"—went to the following men:

Alabama-Mississippi Section—CHARLES MELTON MATHEWS: *for his substantial contributions to the section through technical papers, programs, and official position; his interest in the development of the Mississippi water works short school and legislation for water utility improvements in the state.*

Arizona Section—GEORGE WASHINGTON MARX: *for his many years of assistance to the water utilities of Arizona, fostering practical public health standards, directing research on the effects of fluoride in water supplies, and for his efforts in the training and utilization of qualified operating personnel.*

California Section—LAUREN WILLIAM GRAYSON: *for his many services to the section and his effective and gracious representation of the section in Association affairs, particularly as director, as chairman of the Water Resources Division, and as secretary and chairman of the Management Division.*

Canadian Section—WILLIAM THOMAS RANDALL: *in recognition of sterling support of the Canadian Section for many years as representative of the equipment association on the section's executive, for service on many committees, and for notable assistance in the programs for advancement of the section.*

Chesapeake Section—HARRY BRECKENBRIDGE SHAW: *for his distinguished services to the section and to the Association, particularly his awakening of water utility management to the potential costs of the relocation of utility facilities due to the federal highway construction program.*

Illinois Section—GERALD LEMUAL DAVIS: *for his progressive leadership in the supplying of pure water to the city of Decatur during a long period of plant expansion, for his work in improving and maintaining efficient plant operation, for his promotion of better public relations, and for his years of service to the section.*

Indiana Section—JOHN EMORY KLEINHENZ: *in recognition of his many years of unselfish and devoted service in editing the section newsletter, directing publicity, contributing to the section programs, and for compiling and editing the historical brochure commemorating the fiftieth anniversary of water works meetings in Indiana.*

Iowa Section—PHILIP FAIRBANKS MORGAN: *for organizing and conducting training courses in the technical and administrative aspects of water utility practices; for his leadership in promoting the interest of younger men in water works engineering; and for his unselfish dedication to advancement of the Iowa Section.*

Kansas Section—FRANK ELBERT WILLEY: *for his leadership in organizing the Kansas Section; for planning the orderly expansion of the Topeka water treatment plant; and for his 36 years of service to the water works profession in Kansas.*

Kentucky-Tennessee Section—HAROLD NEIL JERNIGAN: *for devoted service to the section in official capacity of various offices and committee assignments; and for helpful service to water plant operators over and above the call of duty.*

Michigan Section—HERSCHEL O. SELF: *for his outstanding service as manager of one of Michigan's largest water departments; his special capabilities in handling labor-management problems; and his many valuable contributions to the municipal water supply field.*

Missouri Section—LINDON JOHN MURPHY: *for his many years in guiding Missouri students in the field of sanitary engineering; for his tireless efforts in connection with the water plant operator licensing program, the annual operator short courses, and the section's technical conferences.*

Nebraska Section—WILLIAM J. SOMMERS: *for his outstanding success in the design and operation of his city's water system; for so generously extending his time, knowledge, and material aid to water utility operators in smaller towns; and for his deep interest and untiring efforts in section affairs.*

New England Section—WILLIAM ANDREW HEALY: *for his leadership in the improvement of water supplies and water works operation and his distinguished service in the conservation of the water works resources of New England, through water pollution control.*

New Jersey Section—HAROLD MARSHALL OHLAND: *for his outstanding operation of one of the largest municipal water supplies in the state; his service to the joint operation board of the state during emergencies; and his contribution to the section for many years.*

New York Section—JAMES CLARKE HARDING: *for his outstanding work and devoted service to the section.*

North Carolina Section—STANFORD EUGENE HARRIS: *for his enthusiastic years of participation and leadership in all affairs of the section, for his high ethics which have won the love and respect of us all.*

North Central Section—HAROLD HENRY BEHLMER (deceased): *for his many contributions to the advancement of water works practice, including his devoted service to the section as an officer and diligent worker on many committees; and for his accomplishments as head of the water utility of his community.*

Pacific Northwest Section (1958)—CLAUDE VERNON SIGNOR: *in recognition of his excellent work in the water works field and his exemplification of those qualities of leadership and engineering ability which distinguished the life of George Warren Fuller.*

Pacific-Northwest Section (1959)—ERDMAN JERRY ALLEN: *an able engineer, experienced administrator, prudent manager of finances for his department; a tireless leader in advancing the water works profession through capable service as section officer and as a director of the Association.*

Pennsylvania Section—REGINALD BURNS ADAMS: *for his contributions in the scientific field of water treatment; his devoted services for water utility operators; and his active and continued interest in the affairs of the section.*

Southeastern Section—WILLIAM SCHIRMER: *in recognition of his untiring personal and professional efforts in connection with continuous chemical and bacteriological surveillance of the water supplies of his and other states and because of his genuine interest in the establishment of recognized water quality control.*

Southwest Section—FRED HENRY PUCKHABER: *in recognition of his efforts toward diversifying the section's activities; his part in developing and administering the section's scholarship fund; his long service on the section's publication committee and short-school programs; and his more than 25 years of work toward bettering the water utility employee's position.*

Virginia Section—JOHN PHILIP KAVANAGH: *in recognition of his devotion to the precepts of the Association; his able fulfillment of his responsibilities as secretary of the section; and particularly his initiative in reporting section information through newsletters.*

Wisconsin Section—PRESTON ALFRED REYNOLDS: *for his long service in the Rates and Research Division of the Public Service Commission; his valuable contributions to section programs on the subject of water rates; and for his many appearances before the state legislature in the interests of the water industry.*

Schedule of Conference Papers and Reports

MONDAY MORNING, Jul. 13

Water Utility Development Session

Priceless Water—Motion Picture Premiere	American Water Works Assn.
Address of Welcome	*Mayor* G. Christopher
Upgrading the Water Supply Industry	Lewis S. Finch
The Business and Defense Services Administration	Horace B. McCoy
AWWA's Water Utility Advancement Program	*Led by* James B. Corey
Good Utility Citizenship—What It Can Mean	M. M. Jorgensen
Count Down to Oblivion	Robert Gros
Jaycee Community Relations Project	John Taylor

Water Purification Division

Your Water Works—Motion Picture	Cincinnati Water Works
Radioactivity of Surface Waters of the US	L. R. Setter, John E. Regnier & Edward A. Diephaus
Discussion	H. H. Gerstein, Harry P. Kramer, Harold E. Pearson & James C. Vaughn
Water Analysis by Neutron Activation	Harry P. Kramer, R. L. Blanchard, G. W. Leddicotte & D. W. Moeller

Stabilization of Magnesium Hydroxide by Upflow Clarifiers .... T. E. Larson, Russell W. Lane & Chester H. Neff
Effect of Accumulated Lime-Softening Slurry on Magnesium Reduction .... H. O. Hartung & J. L. Tuepker Jr.

MONDAY AFTERNOON, Jul. 13

Water Resources and Water Utility Management Divisions—Joint Session

Canyon Conquest—Motion Picture .... US Bureau of Reclamation
Development of the Upper Colorado River .... Ernest O. Larson
The Philosophy of a Model Water Law .... Arthur M. Piper
East Bay's New Aqueduct .... James W. Trahern
Water Well Stimulation—A Survey of Current Practices .... Louis Koenig
Application of Hexadecanol to a Municipal Water Storage Reservoir .... Morrison B. Cunningham

Water Distribution and Water Purification Divisions—Joint Session

Principles of Coagulation .... A. P. Black
Conversion of Saline Water .... Everett D. Howe
  Discussion .... Sheppard T. Powell, Louis Koenig & Vivian F. Estcourt
New Delhi Hepatitis Epidemic .... Joseph M. Dennis
  Discussion .... Abel Wolman & Richard L. Woodward
Cross-Connection Control—Panel Discussion .... *Led by* Andrew Dempster, Ray L. Derby, E. Jerry Allen & Henry J. Ongerth

TUESDAY MORNING, Jul. 14

Water Resources Division—General Session

Colorado River Aqueduct—Motion Picture .... Metropolitan Water District of Southern California
Progress of the California Water Plan .... M. J. Shelton
Water—America's No. 1 Problem .... Fred A. Seaton
New Jersey's Forward Step in Water Supply .... William J. Orchard
San Francisco's Water Supply .... James H. Turner

Water Purification Division Workshop

Task Group Reports
  Membrane Filters .... J. E. McKee
  Filterability Index .... Joseph M. Sanchis
  Diatomite Filters .... E. Robert Baumann
  Radioactive Contamination .... Harold E. Pearson
  Synthetic Detergents .... Paul D. Haney
  Filter Backwashing .... J. E. McKee
Research Reports
  Water Treatment Effect on Main Capacity .... T. E. Larson
  Protective Coatings for Mains .... Robert F. McCauley
  Chromium and Cadmium Tolerance in Water Supplies .... R. U. Byerrum
  Coagulation .... A. P. Black
  Manganese Problems .... A. E. Griffin
  Chlorine Impurities .... Thomas DeVries

TUESDAY AFTERNOON, Jul. 14

Water Purification Division

The (W)hole Story—Motion Picture .... Armco Drainage & Metal Products, Inc.

Design Criteria for Rapid Sand Filters............................*Led by* John M. Jester, W. W. Aultman, John R. Baylis, H. E. Hudson Jr. & Richard R. Kennedy
A Study of Short Filter Runs With Lake Michigan Water............................ Merrill B. Gamet & John M. Rademacher
Recalcining Water-Softening Sludges—Panel Discussion..........*Led by* William B. Crow
Miami, Fla..C. F. Wertz
Dayton, Ohio..William T. Eiffert
Lansing, Mich...C. R. Erickson

Water Utility Management Division—General Session

River Under the Desert—Motion Picture................American Pipe & Construction Co.
Consolidating Water Systems in California...............................John C. Luthin
The Puerto Rico Aqueduct and Sewer Authority.......................Rafael V. Urrutia
Regional Water Supply Systems—Joint Discussion
Developed by the Central City....................................W. W. DeBerard
Developed by District Authority...................................John W. McFarland
Longe-Range Weather Forecasting as a Water Supply Tool...............Irving P. Krick

WEDNESDAY MORNING, Jul. 15

Water Resources Division Workshop

Pure Water & Public Health—Motion Picture..............Cast Iron Pipe Research Assn.
Weather Control...Fred W. Decker
Discussion...Robert S. Millar
Underground Waste Disposal...Lynn M. Miller
Artificial Ground Water Recharge...John J. Baffa
Erosion Control and Salinity Reduction—Open Discussion

Water Works Administration Committee—Open Session

Radioisotopes—A New Tool for Industry—Motion Picture....UK Atomic Energy Authority
Gas Safety Training—Motion Picture...............................Scott Aviation Corp.
1958–59 Activities of the Water Works Administration Committee.......Wendell R. LaDue
Rating Water Systems—Task Group Report.......................John H. Murdoch Jr.
Job Classifications—Task Group Report..............................Robert S. Millar
Domestic Water Use—Committee Report...............................H. E. Hudson Jr
Pension and Retirement Systems—Committee Report.......................John Copley

WEDNESDAY AFTERNOON, Jul. 15

Water Utility Management and Water Distribution Divisions

The Story of Water Supply—Slidefilm....................American Water Works Assn.
Behind Your Telephone Bill—Motion Picture............Pacific Telephone & Telegraph Co.
Mechanics of Bond Election Campaigns.................................F. H. Eastman
Maintaining Public Support of Water Works Improvements..................Milton Rosen
Discussion...Robert S. Millar
Railroad and Highway Crossings of Water Lines.....................*Led by* Bruce Baty, Herbert J. Chapton, Edward J. Clark, Frank E. Dolson, Roy L. Orndorff, R. Robinson Rowe, Leonard N. Thompson & C. F. Wertz

Water Works Practice Committee—Open Session

Current Activities of the Committees on Cast-Iron Pipe and on Spillways..Raymond J. Faust

Discussions
  Experience With Plastic Pipe
  Epoxy Resins as Protective Coatings
  Standard Designs and Diagrams for Blocking of Pipe Bends, Plugs, and Fittings
AWWA's Interest in International Standards.........S. Logan Kerr
Research on Water Meter Casings.........H. F. Barrett
  Discussion.........Richard C. Reichel
AWWA's Water Works Materials Certification Program.......L. S. Finch & H. E. Jordan

THURSDAY MORNING, Jul. 16

Water Utility Management Division

Water for Everyone—Motion Picture.........Steel Plate Fabricators Assn.
Blue Sky Thinking—The Water Utility of the Future
  As Seen From the West.........William R. Seeger
  As Seen From the East.........Victor A. Appleyard
How Much Does Your Accident Price Tag Show?.........George Sopp
Changes in State Laws Concerning Public Liability.........Gerald Remus
A Quarter-Century of Parallel Operation of a Municipally Owned Water Utility and a Privately Owned Electric Utility.........Peter C. Karalekas

Water Distribution Division Workshop

Lifelines of Your Community—Motion Picture.........Keasbey & Mattison Co.
Tyler, Texas, Elevated Tank—Motion Picture.........The Preload Co.
The Role of the Corrosion Engineer in the Water System.........Paul Beermann
Distribution of Soil Conductivity and Its Relation to Corrosion.........Gordon N. Scott
Ground Storage Versus Elevated Storage.........Marsden C. Smith
The Effect of Valve Operation on Water Hammer.........S. Logan Kerr
  Discussion.........M. B. McPherson

THURSDAY AFTERNOON, Jul. 16

Water Utility Management Division Workshop

Budgeting and Cost Accounting Systems at Work.........J. P. Dieter & C. E. Hemphill
Compensation of Water Works Managers.........Garvin Dyer
  Discussion.........Raymond J. Faust
The Need for Demand Meters—Panel Discussion.........*Led by* George H. Dann
  User's Viewpoint.........Roy Wehe, M. P. Hatcher & W. Victor Weir
  Meter Manufacturer's Viewpoint.........M. E. Hartz, W. P. Hersey & J. F. O'Grady

Social Calendar

Sunday	12:00 Noon	Exhibit Open House	Brooks Hall, Auditorium
	6:00 PM	California Buffet	Vista Room, Whitcomb Hotel
Monday	8:00 PM	Awards and President's Reception	Gold Room, Fairmont Hotel
Tuesday	9:00 AM	Annual Golf Tournament	Presidio Country Club
	9:30 AM	Bus Tour	
	8:00 PM	FUN Night	Main Arena, Auditorium
Wednesday	12:00 Noon	Luncheon and Fashion Show	Peacock Court, Mark Hopkins Hotel
	Evening	No scheduled entertainment	

Thursday	9:15 AM	Ladies Day Golf Tournament	California Golf & Country Club
	2:00 PM	Colonial Tea	Colonial Room, St. Francis Hotel
	6:45 PM	Salute to Harry E. Jordan Dinner & Dance	Garden Court, Sheraton-Palace Hotel

Exhibitors

Adams Pipe Repair Products
Allis-Chalmers Mfg. Co., Hydraulic Div.
American Cast Iron Pipe Co.
American City Magazine
American Pipe & Construction Co.
American Steel Foundries, Pipeline Service Div.
American Well Works
Armco Drainage & Metal Products, Inc.
Badger Meter Mfg. Co.
Baker, R. H., & Co., Inc.
B-I-F Industries, Inc.
Brooks Products, Inc.
Buffalo Meter Co., Inc.
Byron Jackson Pumps, Inc.
Calgon Company Div., Hagan Chemicals & Controls, Inc.
Calmet Meter Div., Worthington Corp.
Centriline Corp.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cla-Val Co.
Clow, James B., & Sons, Inc.
Consolidated Western Steel Div., US Steel Corp.
Crane Co.
DeLaval Steam Turbine Co.
Dorr-Oliver Inc.
Dresser Mfg. Div., Dresser Industries, Inc.
Electro Rust-Proofing Corp.
Engineering News-Record
Fischer & Porter Co.
Fisher Research Lab., Inc.
Ford Meter Box Co., Inc.
Foster Eng. Div., General Controls Co.
Foxboro Co.
Gamon Meter Div., Worthington Corp.
General Filter Co.
Glenfield & Kennedy, Inc.
Golden-Anderson Valve Specialty Co.
Graver Tank & Mfg. Co., Div. Union Tank Car Co.
Greenberg's, M., Sons
Hach Chemical Co.
Hammarlund Mfg. Co., Inc.
Hanks, Fred W., Co.
Harco Corp., Cathodic Protection Div.
Hays Mfg. Co.
Hellige, Inc.
Hersey Mfg. Co.
Homelite, Div. of Textron, Inc.
Hupp Aviation Co., Electrodyne Automatic Valve Operators
Industrial Chemical Sales Div., West Virginia Pulp & Paper Co.
Inertol Co., Inc.
Infilco Inc.
Johns-Manville
Jones, James, Co.
Kaiser Steel Corp., Fabricating Div.
Keasbey & Mattison Co.
Kennedy Valve Mfg. Co.
Koppers Co., Inc., Tar Products Div.
Layne & Bowler, Inc.
Leopold, F. B., Co., Inc.
Link-Belt Co.
Lock Joint Pipe Co.
Ludlow Valve Mfg. Co., Inc.
McWane Cast Iron Pipe Co.
M & H Valve & Fittings Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
National Water Main Cleaning Co.
Neptune Meter Co.
Pacific States Cast Iron Pipe Co.
Pelton Div., Baldwin-Lima-Hamilton Corp.
Permutit Co., Div. Pfaudler Permutit Inc.
Philadelphia Gear Corp.
Pilot Mfg. Co.
Pipe Linings, Inc.
Pittsburgh-Des Moines Steel Co.
Pratt, Henry, Co., Inc.
Preload Co., Inc.
Price Brothers Co.
Public Works Magazine
Rich Mfg. Co. of California
Roberts Filter Mfg. Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co., Inc.
Sherman Products, Inc.
Simplex Valve & Meter Co., Div. Pfaudler Permutit Inc.
Smith, A. P., Mfg. Co.
Smith-Blair, Inc.
Smith-Scott Co., Inc.
Southern Pipe Div., US Industries, Inc.
Sparkler Mfg. Co.
Sparling Meter Co.
Stuart Corp.
Trinity Valley Iron & Steel Co.
Tyler Pipe & Foundry Co.
United Concrete Pipe Corp.
United States Pipe & Foundry Co.
Wachs, E. H., Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Water & Sewage Works Magazine
Water Works Engineering Magazine
Western City Magazine
Wheeler, C. H., Mfg. Co.
Wilgus Mfg. Co.
Willamette Iron & Steel Co.
Wood, R. D., Co.

Papers Scheduled at 1959 Section Meetings

THERE follows a summary listing of papers scheduled for presentation at 1959 section meetings. The dates of the section meetings from 1955 to 1959 and the locations for 1959 are listed on page 1590. Section officers who were elected at meetings held during 1959 are listed on page 2 P&R in the front of this issue. The programs are listed alphabetically by sections, without regard to the date of presentation.

Alabama-Mississippi & Southwest Sections—Oct. 18–21, 1959

Address of Welcome.......................................*Mayor* de Lesseps S. Morrison
Response..Robert L. Lawrence
Expansion of the New Orleans Water Purification Facilities..............Crawford Powell
US Engineers Water Program..L. B. Wilby
The Mississippi River, A Natural Resource.................................Curt Siegelen
Water Works Inventions..John L. Ford Sr.
Adequate and Reliable Fire Protection....................................Kenneth J. Carl
Taste and Odor Experiences in the Southwest Versus the United States....E. A. Sigworth
Prestressed-Concrete Reservoirs..J. J. Closner
Algae and Other Interference Organisms in Water Supplies of the South Central Region C. Mervin Palmer
Advancements in Steel Water Storage Tanks..........................James O. Jackson
The Water Quality Sampling Network as it Pertains to the Southwest Section.............. Ralph C. Palange
Mississippi Embayment Study...Elliot M. Cushing
The Little Fellow Takes on AWWA.......................................Henry Wilkens Jr.
Three Thousand Texans Can't Be Wrong..............................Sam L. Warrington
The Advancement Program: What's In It for Us?........................James B. Corey
The Red River Compact.................Calvin T. Watts, Henry Beckman, Francis Borelli, Leonard White & J. L. Dickson
The Automatic Control of Residual Chlorine....................................A. E. Griffin
Industrial Water Requirements...Cooper Green
Potentials and Problems in the Reclamation of Municipal Wastes.........Bernard E. Berger
Radioactive Monitoring of Water Supplies................James Vaughn & E. C. Tsivoglou
Impoundments.....................................E. C. Warkentin & Forrest O. Swiggart
Test Wells and Well Measurement Data..Philip E. LaMoreaux, Scott Lyles & J. J. Maricelli
Desalination of Water—Panel Discussion........*Led by* Joseph J. Strobel, E. H. Sieveka & Dewey J. Sandell
Anti-Pollution Laws and Their Enforcements............Arthur N. Beck, G. R. Herzik Jr., G. T. Kellogg, K. E. Biglane, Henry M. Jones & H. M. Crane
Electronic Computers in the Water Works Industry.....................Robert S. Gooch
Subdivision Water Extension Policies..................Hollis Conway, Henry L. Dabney & John H. Teunissen

Motion Picture: Priceless Water

Arizona Section—Apr. 16–18, 1959

Address of Welcome..*Mayor* Jack Williams
New Treatment Plant Solves Sewage Problems of Two Cities...........Robert O. Furrow
Special Assessment Districts—The Contractor's Viewpoint....................Vic Fumetti
Operation and Maintenance of Gate Valves..............................H. A. Perkerson
Butterfly Valves in Water and Sewage Service..........................Robert Armstrong
Current Public Health Aspects on Reuse of Sewage and Industrial Effluents................ George W. Marx

Location of Underground Utilities—Who Sets the Criteria?............Otto H. W. Blume
Financing and the Availability of Money for Public Works Projects......Henry L. Roahrig
Electronics and Ground Water..Herb Skibitzke
How Long Should a Water Pipeline Last?...........Russell Stromquist & H. E. Tillman
Schooling and Certification—Panel Discussion................L. O. Henry, H. Bigglestone, K. A. Kirlinger, Roswell Jones & Quentin M. Mees
Motion Pictures: Your Untapped Treasure; Modern Water Treatment

California Section—Oct. 30, 1959

Address of Welcome..*Mayor* Frank Sullivan
Economic Principles for Sound Main Extension Policies..................Charles L. Stuart
Planning Distribution Storage in Non-Hilly Area...........................John R. Fee
Operation of the Coalinga Demineralizing Plant.........................Edmund S. Cary, Henry J. Ongerth & R. O. Phelps
Organization and Management in the Water Works Industry..........Harvey A. Sartorius
The Manager's Function in the Water Works Industry—Panel Discussion................. *Led by* William R. Seeger
Finance...Philip Walsh
Planning...Samuel B. S. Nelson
Day-to-Day Operation...Patrick J. Maloney
Construction...L. Melvin Pollard
Motion Picture: Priceless Water

Canadian Section—May 3–6, 1959

Plant Maintenance—Discussion...*Led by* R. L. Clark
The Application of High Rate Practices in Water Treatment..........E. Sherman Chase & Leonard Millis
Taste and Odor Practices in the United States Versus European Countries..E. A. Sigworth
Miscellaneous Problems in Water Works—Discussion.............*Led by* Lucien L'Allier
A Mutual Aid Program for Water Works..............................John P. Dawson
Safety Programs in Water Works—Discussion...................*Led by* G. H. Strickland
Unaccounted-for Water—What It Costs—Discussion..................*Led by* N. S. Bubbis
Selection and Maintenance of Water Works Pumping Equipment............R. A. Pillman
Water Works Intakes for Canadian Conditions.............................John W. Argo
Architectural Treatment for Water Works Structures...Ronald Harrison & Paul M. Emery

Canadian Section—Maritime Branch—Sep. 9–11, 1959

Miscellaneous Water Works Problems—Discussion...................*Led by* J. W. Lahey
Simplified Automation in a Small Water System...........................Jacques Price
Sewage and Sanitation Problems—Discussion......................*Led by* W. M. Steeves
New Techniques in Ground Water Developments.........................P. O. Bourgeois
Management and Office Procedures—Discussion....................*Led by* W. J. Slattery
Ontario's Water Resources Program...A. E. Berry
Symposium on Civil Defense
Civil Defense in Nova Scotia...Raefe Douthwaite
Civil Defense and the Utility...A. F. Wigglesworth
Water Works in Civil Defense...F. C. Pace
Water Services—Discussion...*Led by* W. E. Seely

Chesapeake Section—Oct. 7–9, 1959

Address of Welcome..*Mayor* J. Harold Grady
Safety..Ira M. Farmer
Potable Water From Saline and Other Supplies......................Lewis von Lossberg
Advancement in Telemetering..David Wood
Abandoned Wells...Turbit M. Slaughter
Discussion..John J. Groot

Radio Communications....................James H. Lee
Accounting for Water Leakage....................Karl H. Schamberger & Roy L. Orndorff
Local Implications of the Water Supply Act....................S. C. Martin & Lloyd Gebhard
Monitoring Radioactivity....................John W. Krasauskas
What is Your Water Plant Worth?....................Edward S. Hopkins
Taste and Odor Control Practices in the Chesapeake Area Versus the Entire United States
E. A. Sigworth
Chlorination Practices....................A. E. Griffin & Robert J. Baker
Discussion....................Gordon L. O'Brien
Selection of Water Pipe Materials for Diameters of 6 Through 24 Inches—Panel Discussion
Led by Kenneth A. McCord, Thomas F. Wolfe, Allen Wirsig, Robert E. Bald & Grant B. Names
Problems Encountered by Water Utilities as a Result of Highway Construction—Panel Discussion....................*Led by* John M. Jester, Robert J. McLeod, Jerome B. Wolff & Richard C. Willson
Motion Pictures: Knowing Is Not Enough; Priceless Water

Florida Section—Nov. 15–18, 1959

Address of Welcome....................*Mayor* Julian B. Lane
Response....................David B. Lee
Response....................Sidney A. Berkowitz
A Look at Florida's Future....................Farris Bryant
Water Well Stimulation—A Review of Current Practice....................Louis Koenig
Converting Upper Tampa Bay Into a Fresh-Water Lake....................Harold A. Scott
Water Treatment Problems....................A. A. Kalinske
Principles of Coagulation....................A. P. Black
Recent Observations of Experimental Waste Stabilization Ponds.....James H. McDermott
Certification and Training of Water and Sewage Plant Operators....George W. Burke Jr.
Rated Aeration....................John Tapleshay
Florida Water Resources—1959....................John W. Wakefield
You've Got Community Relations....................James B. Corey

Illinois Section—Mar. 11–13, 1959

Address of Welcome....................James W. Jardine
The Challenge of Water Management....................Luna B. Leopold
Sanitary Quality of the Illinois River During the Past 50 Years..........Emanuel Hurwitz
The St. Lawrence Seaway and the Growth of Illinois....................Maxim M. Cohen
The Work and Plans of the Northeastern Illinois Metropolitan Area Planning Commission
Paul Opperman
Design Features of the Chicago Central District Filtration Plant.........George S. Salter & Fred G. Gordon
A 50-Year History of Costs and Water Rates....................L. R. Howson
The Mechanics of Establishing a New Water Rate—Panel Discussion.....George H. Jirgal, S. T. Anderson & Clifford H. Fore
Water Utility Advancement....................James B. Corey
Biodata—Panel Discussion....................W. W. DeBerard, A. M. Buswell, L. I. Birdsall, L. R. Howson & J. P. Harris
Nostalgia: Removal of Iron From a Drift Well Water......A. N. Talbot & John B. Stall
Fifty Years Progress in our Knowledge of Water Substance....................A. M. Buswell
Deep Sandstone Aquifers in Northeastern Illinois....................H. F. Smith & W. C. Walton
History of Deep-Well Pump Development....................M. P. Schneller
Report of Study to Improve Treatment of Lake Michigan Water.......J. M. Rademacher & Merrill B. Gamet

Operators Forum—A Discussion........George E. Symons, Gerald L. Davis, Karl J. Fuss, C. E. Corrington, R. E. Favereau, Robert Ireland & L. C. Domke
Water Extension Policies—Panel Discussion............A. G. Giannini, Charles E. Clark & John K. Dorsey
Motion Picture: Pure Water and Public Health

Indiana Section—Feb. 4–6, 1959

Address of Welcome..Leo Louis
The Tradition of the Spas....................................Norman B. Wakeman
Keeping the Man in Management ....Edgar G. Williams
Buymanship for the Water Works Man..............................Richard V. Ford
Location and Development of Ground Water..............................Paul J. Kleiser
Treatment Problems of Ground Water....................................T. E. Larson
Report of a Study to Develop More Effective Treatment of Lake Michigan Water.......... Merrill B. Gamet & John M. Rademacher
Submersible Pumps as Booster Stations....................................F. E. Dolson
Trenching and Shoring..Alden P. Knapp
Cross Connections............................W. D. Shillinger & George G. Fassnacht
A Public Relations Program for the Water Utility Industry................James B. Corey
Operation Helpmeet..Lewis S. Finch

Intermountain Section—Oct. 8–9, 1959

Address of Welcome..H. B. Yearsley
Pipeline Coatings..M. V. Frandsen
Problems of Unmetered Water..Donald F. Lloyd
Coagulant Aids in Water Treatment.....................................Grant K. Borg
Distribution System Storage..A. A. Ross
Attracting and Holding Competent Personnel...............................E. L. Filby
The Water Utility Advancement Program..............................James B. Corey
Origin and Disposal of Radioactive Wastes..............................C. Wayne Bills
Pump Selection and Maintenance—Panel Discussion................*Led by* R. J. Huckabee, Eldon T. McEntire, Allan Mackey & John Smales
Palisades Water for Municipal Use.................................William E. Webb
Motion Pictures: Priceless Water; Living With Radiation; Pure Water and Public Health

Iowa Section—Oct. 14–16, 1959

Address of Welcome...*Mayor* Charles L. Iles
A Water Cocktail (On the Rocks?)...C. F. Wertz
Underlying Factors in Analyzing Industrial Safety........................F. A. Ahlstrand
Solving Water Supply Problem on an Area Wide Basis....................F. W. Edwards
Water Resources: Present Inventory and Future Requirements...........Charles N. Brown
Resistivity Search for Ground Water in Northern Missouri..................W. B. Russell
Recommended Main Extension Policies—Discussion........................George Ahrens
Water Distribution Problems: A Study of Existing Systems and Recommended Sizing...... James Sampson
Dehumidification as it Applies to Water Works Facilities..................M. W. Williams
Auxiliary Power for Water Plants.....................................Edward Farmer
Water Well Stimulation—A Survey of Current Practices....................Louis Koenig
You've Got Public Relations..James B. Corey
Modernizing Public Utility Financial Thinking............................Louis Howson
Developments with Water Rights Law.....................................M. K. Tenny
Certification Program for Water Works Operators.........................Marcus Powell
Short Course for Water Works Personnel.....................................R. L. Morris

Regional Water Works Meetings....................Paul J. Houser
Board of Directors Meeting....................M. K. Tenny
Membership in Iowa Section....................Harris Seidel
Resolutions of Iowa Section....................D. L. Bragg
Use of Sodium Aluminate....................Melvin Williams
Maintaining Chlorine Residuals....................Frank Black
Pipe Breaking—Winter Months....................Richard Wilford
Filtration Rates....................A. L. Bennett
Gravel-Packed Wells....................Charles Brown
Iron Bacteria in Water Supplies....................William Galligan

Kansas Section—Apr. 22–24, 1959

Retirement for Kansas Public Employees....................Allen E. Pritchard
The City's Water Wells....................O. R. Green
The Safe Handling of Chlorine....................J. H. Gregory
Professional Advancement and Community Relations....................James B. Corey
Address of Welcome....................Warren B. Browning
Response....................Stanley M. Smith
What's New In the American Water Works Association....................Lewis S. Finch
An Asia Experience with Water and Sewage....................Herman A. Janzen
Chlorination Experiences....................Warren W. Johnson
The Culligan Approach to Specific Water Problems....................Don Pettit
Hydrogen Sulfide, Its Significance and Removal in a Lime Treatment Plant....................
Leonard L. Sammons
Our Fair Meter Readers....................L. S. McArthur
Radioactivity in Water Supplies....................Russell L. Culp & H. A. Stoltenberg
Motion Picture: Methods of Cleaning Water and Sewer Mains

Kentucky-Tennessee Section—Sep. 14–16, 1959

Address of Welcome....................*Mayor* Shelby Kinkead
Response....................William Hunter Owen
Greetings From AWWA....................L. W. Grayson
Federation Progress....................Ralph E. Fuhrman
Organization, Aims, and Progress of Kentucky Water Resources Commission....................
S. Russell Marshall
You've Got Community Relations....................James B. Corey
Cost of Relocation of Utilities....................Edwin C. Hoskins
Radioactivity in Surface Waters....................Harry P. Kramer
New Aids to Coagulation....................Christopher P. Blakeley
Manganese Problems in Tennessee....................Jack A. Henshaw & Odell W. Gray
The Use of Membrane Filters for Bacteriological Analysis at the Louisville Water Plant
W. L. Williams
Ruling on Water Rates....................E. C. O'Rear
Growing Pains—Panel Discussion..........*Led by* E. E. Jacobson, Robert L. Lawrence Jr., Bert E. Payne, John R. Cook Jr. & E. S. Tillotson

Michigan Section—Sep. 23–25, 1959

Address of Welcome....................*Mayor* Stewart G. Francke
Response....................Leo V. Garrity
News From the Field....................T. L. Vander Velde
New Midland Filtration Plant
Design....................John Seeley
Operation....................Charles A. Froman

Operation Experience with Diatomite Filters.............................C. C. Crumley
Bay City Area Planning...Alex M. Krzyminski
Oakland County Department of Public Works............................Harold Schone
Management—Communications..Russell L. Jenkins
Water Rights Doctrine and a Problem.................................Norman Billings
Bringing AWWA Activities Up to Date..................................C. F. Wertz
Intake Problems—Panel Discussion
  Muskegon...C. T. Mudgett
  South Haven...Max L. Norris
  Design and Intake Structures......................................Stuart Maynard
Employee Relations—Panel Discussion...........*Led by* James Hornung, Herbert Keinath, George Matthews, Carl Nelson & W. F. Marklund
Motion Pictures: Priceless Water; Conference Report; Michigan Means Business

Missouri Section—Sep. 27–29, 1959

Address of Welcome..*Mayor* H. Roe Bartle
Public Relations Aspects of Promoting a Bond Issue........................Ted Sperling
Problems of Easements, Site Acquirement, and Condemnation..........Richard Koenigsdorf
Use of Microstrainers at Denver, Colorado..............................George J. Turre
Radioactivity in Water Supplies.......................................Raphael Daniels
Water Well Stimulation..Louis Koenig
New and Future Equipment in the Water and Sewage Works Field..........A. A. Kalinske
Report of Conference on Tastes and Odors................................Paul D. Haney
Organizing a Research Program Within Your Own Utility.............Nathan C. Burbank
The Value and Use of Records for Water Treatment Plants and Distribution Systems...... Russell G. Kincaid
Pipeline Crossing of the Meramec River.................................E. O. Norman
The Arkansas Compulsory Licensing Program...............................John Luce

Montana Section—Apr. 9–11, 1959

Address of Welcome..*Mayor* Loren E. Stott
Chairman's Address...Carl King
Water Rates and Rate Cases...Clinton J. Hanson
Review of the 1959 Legislature..Al Klinger
Tastes and Odors in Water Supplies.....................................E. H. Sigworth
Sewage Treatment—Panel Discussion..............*Led by* Verne Reed, William J. Wenzel, John C. Voelker, D. F. Cuskelly & T. C. Craft
Address..Lewis S. Finch
Water Works Advancement Program.......................................James B. Corey
Roundtable Discussion...*Led by* C. W. Brinck
Stream Pollution Progress in Montana....................................C. W. Brinck
Motion Pictures: Lifelines for Civilization; Pure Water and Public Health
Filmstrip: Story of Water Supply

Nebraska Section—Apr. 15–17, 1959

Address of Welcome...*Mayor* Bennett Martin
Response...William Sommers
A Community Relations Program for the Water Utility Industry............James B. Corey
Electric Heating..Milton Launer
Lining of Small-Size Pipe.......................................N. Young DuHamel Jr.

Current Legislation of Interest to Utility Departments..................Forrest A. Johnson
Report on the Work of the Inspection Bureau..............................E. C. Wagner
Problems Associated with Sagging Voltages and Short Circuit Currents....John Hansberry
Problems Confronting Small Diesel Plants..........................Elmer W. Jensen
Ground Water Contamination with Special Reference to Synthetic Detergents and Nebraska Conditions...E. C. Reed
Fuels of the Future..George Klein
Employee and Public Safety—Our Number One Job—Panel Discussion....................
Led by Karl M. Joens, Marvin Travis, Earl Fredericksen & William F. Bachman
Motion Pictures: State Stream Pollution Council Report; Torque-Flow Pump

New Jersey Section—Oct. 22–24, 1959

Progress Report on Spruce Run-Round Valley Project....................George Shanklin
Proposed Surface Water Legislation..............Robert L. Hardman & Vinton Thompson
Discussion..........................Richard E. Bonyun, T. W. Coleman & A. J. Greco
Water Well Stimulation—A Survey of Current Practices....................Louis Koenig
Discussion....................................A. C. Schultes Jr. & Virgil F. Every
Radiation Committee Progress Report..........................Charles G. Bourgin
Radioactivity and the Water Works Operator............................Roscoe Goeke
You've Got Community Relations.................................James B. Corey
Civil Service in New Jersey...................................Raymond F. Male
The Public Employee's Retirement System: A Change in Outlook........William J. Joseph
Your Accident Fare—High or Low?......................................Paul Burdan
Discussion..Gordon L. E. Linn
Twenty Questions or More—Discussion......................*Led by* Arthur McConville
Motion Pictures: Priceless Water; Deep Waters; What's In It for Me?

New York Section—Apr. 7–9, 1959

Pumps for Water Works Service..................................George E. Symons
Administrative Procedures for Obtaining Civil Defense Equipment and Supplies............
Marie Driscoll & Raymond Barbuti
Reasons for Mobile Training Team and Use of OCDM Emergency Water Supply Equipment
C. A. Lombardi
Reversible Filtration...Judson C. Brown
Water and Industry..William Helmrich
Competitive Bidding Requirements in New York State....*Led by* Morris Cohn, Harry Metz. E. J. Clark, L. J. Griswold, E. S. Dennison & A. J. Frank

New York Section—Sep. 16–18, 1959

How to Obtain Speaking Engagements...................................W. T. Miller
How to Make and Show a Movie..................................John E. Kleinhenz
How to Make a Talk..George E. Symons
Probable Accuracy for Proportional Pacing Systems........................Frank Russo
Rehabilitation and Stimulation of Water Wells............................Louis Koenig
Municipalities, Contractors, and Engineers—A Lawyer's Viewpoint....Edgar A. B. Spencer
Radiological Fallout and Civilian Defense................................C. M. Taylor
Radioisotopes in Water—Their Measurement and Removal—Panel Discussion..............
Led by R. O. Schindler, Raymond Barbuti, James E. O'Brien & Marie Driscoll
Motion Picture: Pure Water and Public Health

North Carolina Section—Nov. 9–11, 1959

Address of Welcome..*Mayor* E. G. Evans
New & Interesting Features of the City of Durham's Water & Sewer Department Operations—Panel Discussion........*Led by* Wade G. Brown, J. A. Andrea, W. L. Dunlap, W. Paul Fuller, J. R. Malone, Leslie Matthews & J. S. Welch
Financing of Water & Sewer Improvements in Municipalities...........W. E. Easterling
Revision of the Public Health Service Drinking Water Standards..Richard L. Woodward
State of North Carolina's New Water Resources Department............Harry E. Brown
The Economics of Two-Way Communication in Water & Sewer Functions—Discussion... *Led by* Leonard P. Bloxham
  Meter Reading with Two-Way Radio..................................J. E. Hinkle
  Economics and Use of Two-Way Radio in the Water and Sewer Industry.....E. G. Bond
  New Innovations in Two-Way Communication
Motion Pictures: Pure Water and Public Health; Alaska Pipeline

North Central Section—Sep. 16–18, 1959

Address of Welcome..........................*Police Superintendent* Milton E. Winslow
Response...Arthur T. Hanson
Types of Treatment Plants...James Dornbush
Basis of Design—Surface Waters...........................Arndt Duvall & C. S. Barger
Basis of Design—Well Waters.......................................William Schoell
Chemical Treatment...M. O. Thomas
Controls in Treatment Plants......................................Ray W. Lindsey
Pumping Station Design...A. W. Banister
Pumps—Types and Sizes...Howard Godfrey
Pumps—Testing and Efficiency...Frank Srdar
Pump and Pumping Station Controls.................................Thornton Lyford
Pump Maintenance...L. P. Steiling
Cast-Iron Pipe—Installation and Maintenance......................Leonard Parnell
Valves—Installation and Maintenance...................................Roy Holzer
Hydrants—Installation and Maintenance...........................Ned Van Wambeke
Meters—Installation and Maintenance...............................Robert Wigley
Location and Size of Storage Facilities............................Earl N. Ruble
Concrete Reservoirs...C. P. Shelander
Elevated Tanks..Harry E. Douglass
Reservoir and Tank Controls.......................................John A. Gardeen

Ohio Section—Oct. 28–30, 1959

Pumps: Centrifugal, Deep Well, and "In-the-Line"—Panel Discussion..*Led by* John Harmon, C. K. Dye, Howard Godfrey & Edward Rudnicki
Address of Welcome.....................................*Mayor* R. William Patterson
Eyes of the Future—Panel Discussion................*Led by* O. J. Sirola, Quinn Peters, Joe Angel, Edgar B. May & Charles O. Anglin
Chemical Feeding: Liquids and Slurries............................V. W. Langworthy
Cincinnati Metropolitan Water Works...............................William Sahnd
Stabilization Versus Encrusted Sand.................................A. P. Black
Split Treatment Versus Carbon Dioxide..............................Paul D. Haney
Behind the Faucet..Charles M. Bolton
The Extension of Water Service Outside Municipal or Corporate Limits—Panel Discussion.. Gene E. Cronk, Paul D. Cook, Henry J. Crawford, Desso T. Mitchell & Leslie G. Wolfe
Recent Advances in Equipment and Techniques of Water Analysis.......Stephen Megregian
The Relining of Two 5½-in. Square Filtered-Water Conduits Under Pressure..Roy M. Mumma
Recalcining Water Softening Sludge at Dayton.......................William T. Eiffert
Water Legislation of the 103rd General Assembly....................C. V. Youngquist
Unusual Water Works Stories and Experiences—Discussion.........*Led by* M. V. Tatlock
Chlorine Safety Program...Frank O. Wood

The 1959 Floods: Public Works Experiences in Affected Ohio Communities...John S. Hess
You've Got Community Relations....................................James B. Corey
Legislative Report....................................Raymond Fuller
Motion Picture: Pure Water and Public Health

Pacific Northwest Section—Apr. 22–24, 1959

Address of Welcome....................................*Mayor* A. T. Ashbury
National Board of Fire Underwriters Criteria for Water System Grading and Design...... Carl A. Weers
Type and Significance of Chlorine Residuals....................................Robert J. Baker
Water District Personnel—Discussion....................................*Led by* Patrick H. Deeny
Paints and Painting for the Water Works Industry....................................C. G. Munger
Turbine Pumps for Booster Service....................................C. C. Warren
Water Works Management....................................Wendell R. LaDue
The Water Works Advancement Program....................................James B. Corey
Cold Weather Distribution System Operation....................................G. P. Harford
Discussion....................................Amos J. Alter
Leakage Surveys....................................Robert E. Mielke
Easy Does It—Discussion....................................*Led by* Robert L. Lee
The Role of Activated Carbon in Water Purification....................................E. A. Sigworth
The Hanford Experimental Filter Plant....................................W. R. Conley
A Report of the Water Purification Committee....................................Winston Berkeley
Motion Pictures: Pipelines to the Future; An Introduction to Back-Siphonage; From Plans to Plenty; Pipe—What You Would Like to Know; Water for Everyone; Water for the West; Lifelines for Civilization

Pennsylvania Section—Jun. 3–5, 1959

Forestry in Water Operations....................................James F. Heagy
Handling Customer Complaints....................................Carl W. Frey
Greetings From AWWA....................................Lauren W. Grayson
The Role of the Biologist in Water Studies and Treatment....................................Charles B. Wurtz
You've Got Community Relations....................................James B. Corey
Relation Between Flow Rates, Fluoride Content, and Hardness Content of Allegheny River Water....................................Gerald J. Cox
The Brandywine Water Supply and Flood Control Project....................................Clayton M. Hoff
Allocation of Water Supplies....................................Maurice K. Goddard
Legislation for Certification of Water Works Operators....................................Lawson D. Matter
Determination of Aluminum in Water....................................Kenneth E. Shull
Motion Pictures: These Are the Facts; Pure Water and Public Health

Rocky Mountain Section—Sep. 8–10, 1959

Why Water Treatment?....................................Arthur E. Williamson
Testing for Radioactivity in Water Works Supplies....................................George Turre
The Art of Making Friends....................................James B. Corey
The Sportsman and the Polluted Stream....................................Robert Kimball
A Community Relations Program for the Water Works Industry....................................James B. Corey
The Detergent Problem....................................Ralph House
Metering Policies....................................Jack Maguire
Federal-Aid Programs....................................Kaarlo Nasi
Location of Wells for Ground Water Development....................................George H. Chase
Submersible Pumps or Vertical Turbines....................................John Bayless
Operator Certification....................................Howard Lewis
Application of Variable Speed Pumping....................................Tom G. Gressett
Paints and Coatings for Water Works....................................Andy Lobel

Water Rates & Charges....Clarence Hoper
Ion Exchange in Water....Jack Sampson
Sanitary Projects of New Mexico....Charles G. Caldwell

Southeastern Section—Apr. 5–8, 1959

Address of Welcome....*Mayor* Lester L. Bates
The Columbia Water Works System....Harry O'B. Bellinger
Are Agricultural Insecticides Damaging Our Water Resources?....H. P. Nicholson
The Membrane Filter for Testing Water..J. A. Boyer, A. T. Storey & Elizabeth McEntire
Water Works Administrative Problems.....Joseph H. Sanders Jr. & John W. Sholenberger
Water Resources Control—State and Federal—Panel Discussion....
Led by Alan McC. Johnstone, Wade H. Padgett Jr., Clair P. Guess Jr. & W. T. Linton
Professional Advancement and Community Relations Program of AWWA...James B. Corey
New FCC Regulations Concerning the Use of Utility Radio and Their Effect Upon Radio Users....John W. Crews
Checking Meter Readings by Radio....James E. Hinkle
Evaluation of Water Works Design—Panel Discussion....*Led by* B. P. Barber, Emory C. Matthews, W. H. Weir & J. M. Roberts
Safety Committee Activities....Roy Ruggles

Southwest Section—Oct. 18–21, 1959

Joint meeting with Alabama-Mississippi Section (see p. 1579).

Virginia Section—Nov. 4–6, 1959

Sludge Contact Clarification Units....H. G. Ragland Jr.
Short-School Committee Discussion....J. G. Jones
Operators of Certification Program—AWWA Representative Report......W. W. Anders
Accident Prevention Committee Report....W. G. Beazley
Roanoke's New Meter Maintenance Program....Carmon E. Hylton
Outside Demonstration of Mobile Meter-Testing Unit....Carmon E. Hylton
New Aids to Coagulation....Christopher P. Blakeley
Water Rates—Panel Discussion....*Led by* E. C. Coalson, R. D. Wright & Merrill L. West
Water Well Stimulation—Survey of Current Practices....Louis Koenig
Water for Suburbia—An Authority Approach to the Problem.......James J. Corbalis Jr.
The Place for Automatic Controls in a Filter Plant....William J. Firth
You've Got Community Relations....James B. Corey
Life's Most Precious Commodity....John Wynn Myers
Motion Picture: Pure Water and Public Health

West Virginia Section—Oct. 27–29, 1959

Address of Welcome....*Councilman* Cecil Coffield
Pumping—Submersible Versus Standard Deep Well Turbines....Richard S. Baugh
Porous Plate Filter Bottoms....Frank C. Roe
Recent Improvements to the Parkersburg Water System....Cecil Coffield
Address....Lauren W. Grayson
Address of Welcome....*Mayor* Clarence W. Hylbert
America Will Grow "Up" As It Grows "Down"....Morris Cohn
Water and Its Meaning to West Virginia....Walter Gumbel
Rate-Making Procedure and Problems of Financing Improvements.......Myron C. Rennick
Water Works Advancement Program....James B. Corey
Separation of the Water Utility From General City Government......H. William Largent
Present Status and Future Possibilities of Extended Weather Forecasting....Jerome Namias

The United States in 1975 .... Richard J. Anderson
Motion Pictures: Pure Water and Public Health; Aeration in Deep Wells; Good Business

Wisconsin Section—Sep. 9–11, 1959

Address of Welcome .... *Mayor* Frank P. Zeidler
Opening Remarks .... Arthur J. Jark
Water Use in Wisconsin .... Harvey E. Wirth
Rotary Drilling and Its Application to Water Wells .... William A. McEllhiney
Taste and Odor Conditions in the United States Versus Europe .... E. A. Sigworth
Phosphates for Iron, Manganese, and Corrosion Control .... Ceaser A. Stravinski
Certification of Water Works Operators .... William U. Gallaher
Water Works Advancement .... Leroy J. Beckman
Water Resources .... Arthur J. Jark
Water Works Safety .... William Hammann
AWWA Membership .... Edmund T. Malinowski
Installation of Mains, Valves, and Appurtenances .... Everett Westfahl
Proper Maintenance of Distribution Facilities .... Clyde Collins & Robert J. Poss
Financing Water Utility Improvements .... John F. Baumann
You've Got Community Relations .... James B. Corey
Motion Picture: Conference Report

Correction

The article by Carl F. Lind, "Hydraulic Uses for Asphalt" (March 1959 JOURNAL, Vol. 51, pp. 418–422), contained several erroneous statements. On p. 418, in col. 2, the final paragraph should be amended to read:

For buried membranes an air-refined asphalt having special properties and a softening point of 175°–200°F is usually used. The asphaltic membrane must be continuous, unbroken, and free from "holidays," or open areas. This requires from 1.25 gal/sq yd of asphalt over a smooth subgrade to as much as 2.00 gal/sq yd over a very rough subgrade. Over a very rough subgrade, a tough asphaltic membrane, $\frac{5}{16}$–$\frac{3}{8}$ in. thick, is necessary. The membrane should ordinarily not be placed on slopes steeper than 2:1.

Section Meetings—1955–1959

Section	*1955*	*1956*	*1957*	*1958*	*1959*	*Meeting Place—1959*
Alabama-Mississippi	Oct. 30–Nov. 2	Oct. 21–24	Oct. 20–23	Sep. 28–Oct. 1	Oct. 18–21	New Orleans, La.‡
Arizona	Apr. 14–16	Apr. 5–7	Apr. 4–6	May 15–17	Apr. 16–18	Phoenix, Ariz.
California	Apr. 15*	Apr. 13*	Apr. 26*	—	—	—
	Oct. 25–28	Oct. 23–26	Oct. 29–Nov. 1	Oct. 28–31	Oct. 30	Bakersfield, Calif.
Canadian	Apr. 18–20	Apr. 23–25	Jun. 17–19	Jun. 1–4	May 3–6	Montreal, Que.
	Oct. 17–18†	Oct. 15–16†	Oct. 17–18†	Oct. 1–3†	Sep. 9–11†	Liverpool, N.S.
Chesapeake	Oct. 26–28	Oct. 24–26	Oct. 30–Nov. 1	Oct. 29–31	Oct. 7–9	Baltimore, Md.
Cuban	Dec. 1–3	Nov. 29–Dec. 1	§	—	Nov. 19–21	Havana, Cuba
Florida	Nov. 6–9	Nov. 11–14	Nov. 10–13	Oct. 19–22	Nov. 15–19	Tampa, Fla.
Illinois	—	Mar. 21–23	Mar. 20–22	Mar. 26–28	Mar. 11–13	Chicago, Ill.
Indiana	Feb. 9–11	Feb. 8–10	Feb. 6–8	Feb. 5–7	Feb. 4–6	French Lick, Ind.
Intermountain	—	—	—	Nov. 6–7	Oct. 8–9	Pocatello, Idaho
Iowa	Oct. 19–21	Oct. 24–26	Oct. 16–18	Oct. 15–17	Oct. 14–16	Des Moines
Kansas	Apr. 13–15	Apr. 4–6	Apr. 10–12	Mar. 12–14	Apr. 22–24	Pittsburg, Kan.
Kentucky-Tennessee	Sep. 12–14	Sep. 17–19	Sep. 23–25	Sep. 22–24	Sep. 14–16	Lexington, Ky.
Michigan	Sep. 14–16	Sep. 12–14	Sep. 25–27	Sep. 8–10	Sep. 23–25	Saginaw, Mich.
Missouri	Sep. 25–27	Sep. 30–Oct. 2	Sep. 29–Oct. 1	Sep. 28–30	Sep. 27–29	Kansas City
Montana	Apr. 29–30	Apr. 6–7	Apr. 4–6	Mar. 20–22	Apr. 9–11	Glendive, Mont.
Nebraska	Apr. 13–15	Apr. 11–13	Apr. 24–26	Apr. 16–18	Apr. 15–17	Lincoln, Neb.
New England	—	—	—	—	—	—
New Jersey	Oct. 20–22	Oct. 18–20	Oct. 24–26	Oct. 23–25	Oct. 22–24	Atlantic City, N.J.
New York	Apr. 20–22	Apr. 18–20	Apr. 10–12	Mar. 26–28	Apr. 8–10	Rochester, N.Y.
	Sep. 7–9	Sep. 12–14	Sep. 11–13	Sep. 10–12	Sep. 16–18	Upper Saranac Lake, N.Y.
North Carolina	Nov. 14–16	Nov. 12–14	Nov. 11–13	Nov. 10–12	Nov. 9–11	Durham, N.C.
North Central	Oct. 5–7	Sep. 12–14	Sep. 25–27	Sep. 24–26	Sep. 16–18	Minneapolis, Minn.
Ohio	Sep. 21–23	Sep. 19–21	Sep. 18–20	Sep. 17–19	Oct. 28–30	Dayton, Ohio
Pacific Northwest	May 19–21	Apr. 26–28	May 2–4	May 15–17	Apr. 23–25	Vancouver, B.C.
Pennsylvania	May 4–5	Apr. 3–5	Jun. 12–14	Jun. 25–27	Jun. 3–5	Wernersville, Pa.
Rocky Mountain	Sep. 19–21	Nov. 26–28	Sep. 23–25	Sep. 15–17	Sep. 8–10	Moran, Wyo.
Southeastern	Mar. 20–23	Mar. 18–21	Mar. 17–19	Mar. 23–25	Apr. 5–8	Columbia, S.C.
Southwest	Oct. 16–19	Oct. 14–17	Oct. 13–16	—	Oct. 18–21	New Orleans, La.‡
Virginia	Nov. 3–5	Nov. 7–9	Nov. 6–8	Nov. 5–7	Nov. 4–6	Roanoke, Va.
West Virginia	Oct. 20–21	Oct. 31–Nov. 2	Oct. 23–24	Oct. 23–24	Oct. 28–29	Parkersburg, W.Va.
Wisconsin	Sep. 21–23	Sep. 26–28	Sep. 4–6	Sep. 17–19	Sep. 9–11	Milwaukee

* Regional meetings. † Maritime Branch. ‡ Joint meeting of the Alabama-Mississippi and Southwest sections. § Meeting canceled.

Section Membership at Time of, and Total Attendance at, Section Meetings—1955–59

Section	1955		1956		1957		1958		1959	
	Membership	Attendance	Membership	Attendance	Membership	Attendance	Membership	Attendance	Membership	Attendance
Alabama-Mississippi	206	257	219	318	224	307	235	279	253	225
Arizona	68	157	77	156	84	234	104	170	107	260
California§	1,291	1,037	1,378	1,253	1,451	1,225	1,601	1,710	1,728	470#
Canadian§	629	714	663	816	708	500	730	922	753	910
Chesapeake	258	211	267	191	288	228	306	157	310	230
Cuban	54	*	52	43	62	‖	58	†	56	43
Florida	342	306	355	331	361	399	385	460	377	*
Illinois	527	‡	557	468	589	474	650	509	707	811
Indiana	392	475	409	421	478	499	525	602	538	429
Intermountain	**	**	**	**	**	**	76	107	107	108
Iowa	137	286	149	220	181	282	189	289	208	277
Kansas	229	208	237	236	239	217	259	228	257	223
Kentucky-Tennessee	201	259	221	317	252	317	268	368	268	344
Michigan	411	236	435	278	471	341	505	335	528	408
Missouri	206	230	228	275	238	306	246	289	251	320
Montana	57	76	54	84	61	132	64	154	63	115
Nebraska	94	164	103	183	109	156	107	63	104	143
New England	225	†	233	†	248	†	258	†	271	†
New Jersey	435	313	463	351	505	336	531	370	543	381
New York§	826	315	851	429	882	458	884	505	923	540
North Carolina	202	281	232	326	224	305	215	*	203	335
North Central	238	162	260	157	278	177	260	199	255	181
Ohio	468	251	482	253	508	281	517	334	522	378
Pacific Northwest	440	293	438	304	507	358	500	398	481	391
Pennsylvania	493	255	516	295	558	235	560	251	566	258
Rocky Mountain	171	94	186	164	237	152	205	166	209	140
Southeastern	267	325	278	319	300	335	326	446	315	367
Southwest	1,047	850	1,086	889	1,133	784	1,113	‡	1,090	1,062
Virginia	192	237	207	233	213	241	216	216	214	228
West Virginia	100	152	104	126	105	195	112	201	121	194
Wisconsin	190	291	199	296	206	340	216	319	220	324

* No record of attendance.
† No regular meeting scheduled. Membership given as of dates of conferences.
‡ Regular meeting canceled. Business meeting held at annual conference.
§ Only one of section's meetings recorded here.
‖ Meeting canceled.
A one-day meeting, because the annual conference was held in San Francisco.
** Section organized in 1958.

V.51 (1959)

Subject Index

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Author Index

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Jul. 821–952; Aug. 953–1060; Sep. 1061–1190; Oct. 1191–1330; Nov. 1331–1472; Dec. 1473–1612

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Binding the Year's Journals

Arrangements have been made by AWWA for members and subscribers to have their JOURNALS bound into distinctively designed volumes, with the JOURNAL masthead, AWWA seal, volume number, and year stamped in gold on the spine.

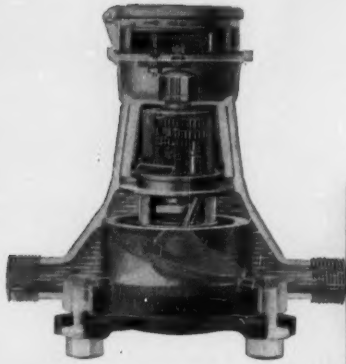
The price for such a binding, using the best grade of indigo blue washable buckram, and with your name imprinted on the front cover, is $4.15. (This price is for binding into one volume the text sections of the twelve issues, January through December, including the table of contents and text indexes for the year—from the December issue—but omitting the advertising sections and paper covers.)

Ship your journals parcel post, together with full remittance (check or money order) and address to which bound volume should be sent, to:

Publishers' Authorized Bindery Service, Inc.
5811 W. Division St.
Chicago 51, Ill.

Before you ship, check for missing issues and check each issue for defects, missing pages, etc. Pack carefully so that nothing is crumpled or torn. The bindery will forward the bound volume within 30 days of receipt and will ship prepaid anywhere in the United States.

A microfilm addition of the JOURNAL is available to regular subscribers from University Microfilms, 313 N. First St., Ann Arbor, Mich. The cost of the microfilm edition of the 1958 volume was $9.60.



HOW TO DEVELOP MORE *EFFICIENCY* IN YOUR METER SHOP

It takes money to maintain the water supply your community expects. It's vitally important to make sure all the water pumped is paid for . . . by using accurate meters . . . and by keeping these meters in good repair.

When a meter man learns one Trident, he learns them all. Instead of spreading his knowledge thin over many types and models of household meters, he can concentrate on the fine points of just one, and can quickly learn to do a job of which he can be proud.

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neptune
TRIDENT WATER METERS

Merry Christmas

Going like 60 * was P&R in '59—like the 60 members of Editors Anonymous, that is, who made this twelfth twelvemonth of P&Rrticles possible. And if the growing list of these contributors to the stuff of which P&R is made would seem to indicate a growing need for help in this department, who are we to dispute such an evocative conclusion? As a matter of fact, to make the evocative more provocative, we're even willing to admit that we plan to continue this December disanonymization of our assisters underdeskinned, as well as to continue protecting their skins by inter-Decembral innomination.

Lest you fail to penetrate this verbal smog, be assured that our intent in the belowly listing of our 1959 accomplices is strictly gratitudinous. We should make clear, too, that the power with which each is invested is a record of the number of years that he has been a member of the secret staff of P&R. And it behooves us to point out that the All-Anonymous three—Ellsworth Filby, Joe Wafer, and Syd Wilson—have now been fortified by a fourth, previously undisanonymized by reason of his position. Now that it can no longer compromise him, we are happy to add the powerfull name of Harry Jordan to the list, and to note that not only his contributions to, but his encouragement of, P&R-ticulation have been preeminent in its preservation.

Lest you fail, too, to appreciate the need for P&R preservation, let us remind you of the season and ask you to join us in wishing a Merry Christmas to our

EDITORS ANONYMOUS

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* But growing like 64, four more silent partners having fortified the rolls of EAers between typewriter and type.

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R. S. Phillips[1]
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Henry Wilkens[7]
D. B. Williams[8]
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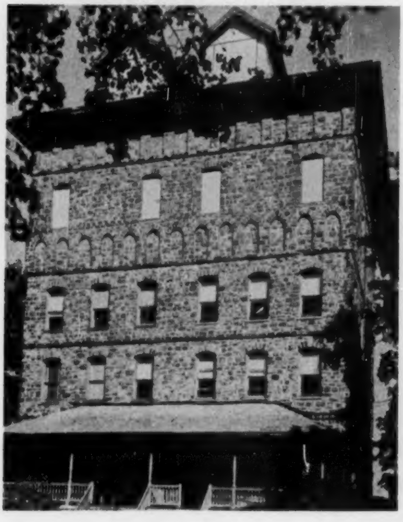
A Happy New Year, too, we say, hoping that '60 will go like 90!

Water on top—thousands of gallons of it—is the story of the two unusual buildings pictured below. That the substantial structure at the left is also mostly subaqueous isn't very obvious, but it was built by the Ambler (Pa.) Water Co. primarily as a storage place for its water supply and only incidentally as a residence for employees who did not object to having their work uppermost in more than their minds. Designed by Richard V. Mattison, cofounder of Keasbey & Mattison Co., the building was constructed in 1904 of stone taken from the same quarry that supplied the spring water to be stored and was topped with the nation's first asbestos-cement shingle roof. Directly under those shingles are five wooden 20,000-gal tanks to which the quarry water was pumped. Although it ceased to function as a storage facility in 1940, the "Tower House" is still a residence—with five swimming pools in the attic yet!

More picturesque—or perhaps we should say shapely—is the Aldborough (England) cottage shown at the right. Occupied now by Capt. Harold W. Ridge, USAF, his wife, two daughters, and 28,000 gal (Imp.) of water for supplying surrounding Suffolk folk, the cottage has been a landmark ever since "an artistically minded lord of the manor" built it "many (Imp.) years ago." In addition to a steel tank at the top, the structure contains fifteen rooms on five stories—which



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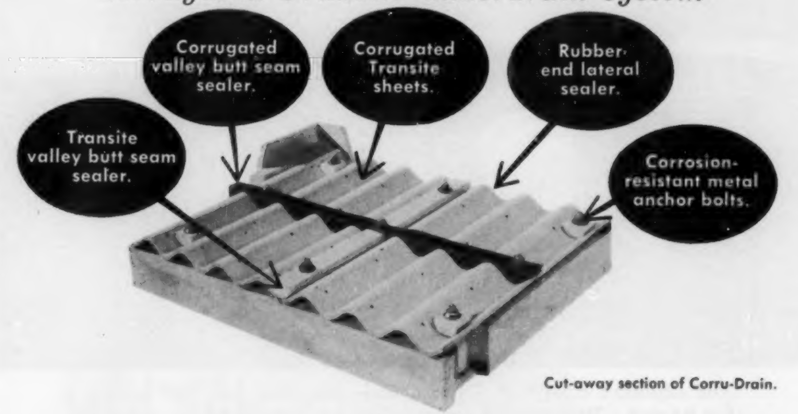
BOTTOM YOUR FILTERS
this NEW Way

CORROSION-RESISTANT, LONG-LASTING

CORRU-DRAIN

corrugated Transite underdrain system



Cut-away section of Corru-Drain.

- Maximum Backwashing Efficiency—tangential upward flow prevents movement of gravel.
- Light Weight—2500 lbs. for 1 million gallon capacity.
- Simple, Fast Installation—estimated 0.22 man-hours per sq. ft. or less than half the time required for other systems.
- Structural Strength—tested for 4800 lbs. pressure per sq. ft.

Every component of Corru-Drain is COMPLETELY CORROSION-RESISTANT. Corrugated design does away with construction of concrete piers, preset anchor bolts, access man-holes. Comes in 6 ft. sheets, easy to install in record time. You save in shipping, handling, maintenance—have an underdrain that will outlasts all other types. Performance is proved in actual installation, confirming optimum backwashing distribution with virtually no movement of gravel.

write for descriptive literature

use Corru-Drain for new filters or conversion of existing units

GRAVER

Municipal Dept. M-430
GRAVER WATER CONDITIONING CO.
Division of Union Tank Car Company
216 WEST 14TH STREET, NEW YORK 11, N.Y.

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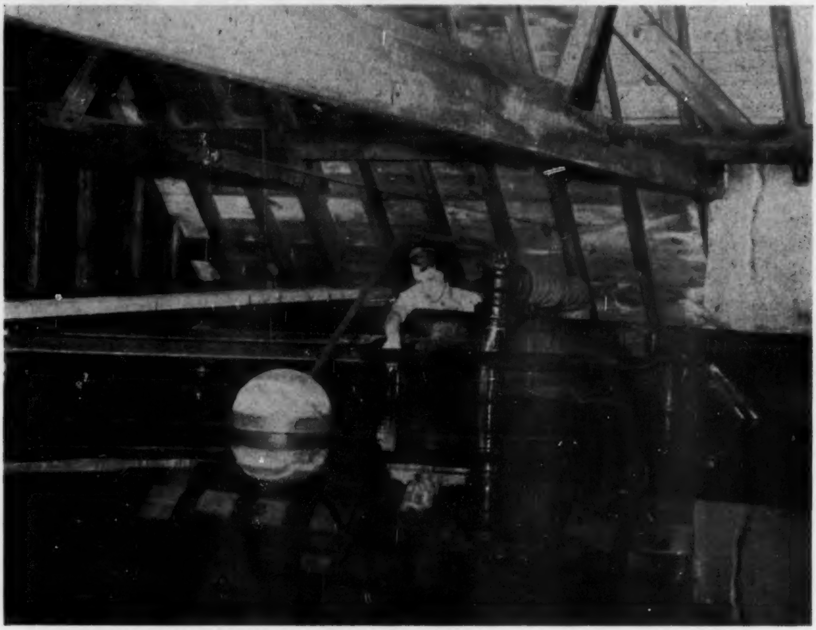

The captain's daughter, Donna, finds her attic full, but hardly a fire hazard. When the float valve sticks, the neighbors rouse the Ridges.

allows Capt. Ridge, who is field maintenance officer at nearby Bentwaters Air Base, to unbend to his heart's content when he gets home.

But, yoohoo, you who have elevated storage and depressed rates, why not become a land as well as water lord?

Bubble-headed is what they called Willing Water when they featured him in the Pasadena *Independent* and the *Star-News* last month as the guide to the water department's exhibit in the main corridor of city hall. All of which might provoke us to ask Pasadenans what kind of bubbles they blow, anyway, but just seeing Willie at work and in the headlines in still another city makes us much too happy to say anything untoward. Elsewhere in California, however, we have been rather disappointed to note that the Feather River Project Assn. has adopted a poor imitation of Willie to help sell the 1.75-billion-dollar bond issue required to carry on the California Water Plan. It isn't that we disagree with "Ricky Raindrop" when he points out that "Prosperity for All California Begins With WATER." We just think he's a little presumptuous—a little wet behind the ears—a young squirt, that is—to be taking on a job that really needs Willing Water. After all, this is no rainmaking project!

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Hersey Mfg. Co., Dedham, Mass., has announced a merger with Sparling Meter Co., El Monte, Calif., to take effect in January. The combined organization will be named Hersey-Sparling Meter Co., with Winthrop P. Hersey as president and Ray C. Sparling as vice-president. Executive offices will be in Dedham.

The West Virginia Section is justly congratulating itself on the success of the short course it sponsored earlier this year in cooperation with the state health department and West Virginia University. The curriculum included classroom and laboratory work in various phases of water treatment, together with such subjects as corrosion control, distribution system operation, and record keeping. In the photo below, members of the faculty and 25-man student body pose in front of the University Medical Center buildings, where the course was held.

The Albany Rock, who has been making more of a splash these days than even the Plymouth Rock, has managed to send at least a ripple or two into the field of public water supply. First official notice of this was when AWWA's Publication Committee Chairman E. Shaw Cole was presented as first character witness in Stewart Alsop's *Saturday Evening Post* (Jul. 25) and *Reader's Digest* (October) story, "The Strenuous Career of Nelson Rockefeller." There the tie-in was one of classmate-friend, however, and not water worker. It was an earlier, though long unnoticed, direct contact with water that caused us even more stir. That was a proclamation issued on Jun. 15 to the following effect:

With every year the problem of our water resources becomes of more imminent moment. The New York Legislature has taken the lead in exploring its complex aspects. But this vital matter needs the

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cooperation of all of the people of the state, particularly in the conservation of our existing supply.

The American Society of Sanitary Engineering [for Plumbing and Sanitary Research] estimates that hundreds of millions of gallons of water are wasted every day in New York State.

With our natural growth in population, this can produce a problem of unlimited dimensions.

The needless waste of water can be curtailed if all of us, men, women, and children, will cooperate to stop the squandering of our priceless heritage. Each user of water should be alert to this necessity.

Now, therefore, I, Nelson A. Rockefeller, Governor of the State of New York, do proclaim the period Jun. 24–30 as WATER CONSERVATION WEEK in New York State and I call the attention of communities, organizations, and individuals to the momentous nature of this problem.

Although we would have put a quite different emphasis on a water week, we cannot be too unhappy about anything that calls the attention of the public to public water supply. And certainly we, too, are against "needless waste," or, for that matter, waste of any kind. But we would have been a lot happier about an "Improved Water System Week," for instance, for New York State's water problems are certainly more a matter of shortage of facilities than shortage of resources. As a matter of fact, New York City claims to be all set to take care of its water needs until at least the turn of the century, and such an indication as the full-page Niagara-Mohawk advertisement in the October issue of *Fortune* suggests anything but shortage, in saying:

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Looking for Water . . . Come to "Upstate, N.Y.," new market place of the world. Plentiful water is vital to industrial growth and expansion. You'll find it in abundance in Upstate, N.Y.'s lakes, rivers, and year 'round high water table.

Lest our praise seem faint, though, it is damming rather than damning that we would like to accomplish, for therein certainly lies the most effective conservation.

At any rate, if we can really get the Rock into water, its level is bound to be raised.

Morris Cohn, editorial director of *Water Works Engineering* and *Wastes Engineering,* has gone abroad to survey treatment and pollution control practices in Europe, and to represent FSIWA at a meeting of the Israeli Assn. of Sanitary Engineers. While in Israel, he is scheduled to lecture at the Institute of Technology in Haifa

Water rocketeering gives some indication that another branch of military science is about to yield some peaceful byproducts. Thus, on a somewhat more modest scale than the Atlas or the Jupiter or the Pioneer, are the H_2O, the Hailbuster, and the Rainmaker.

The H_2O, as a matter of fact, is no more than a two-stage plastic toy, propelled by a combination of water and compressed air, to a second-stage height of approximately 350 ft. The toy, with its now rather unstylish Air

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Force markings, required a full year of engineering research to perfect; it sells for $10. The Hailbuster and Rainmaker, on the other hand, are working rockets, not much larger in size, at 3 ft, than the toys, but propelled by more potent fuel at a speed of 375 mph into the upper atmosphere. They carry warheads of silver iodide that burst and scatter their crystals in the clouds, the one to prevent hailstorms from damaging crops, the other to induce rain to augment water supplies and irrigate crops. Invented by an Italian scientist, Angelo Patti, these two missiles are being used extensively throughout the farm areas of Italy and the Soviet Union.

After all the talk of guiding H-bombs into other people's backyards, it's a relief to think of a rocket as a lot of toys or a missile as submissive—watered down, that is, and, therefore, more beneficial, of course!

Crane Co., Chicago valve manufacturer, has purchased Chapman Valve Mfg. Co., Indian Orchard (Springfield), Mass. Chapman will continue under its present name and management as a wholly owned subsidiary of Crane.

A. V. DeLaporte, director, Div. of Labs. & Research, Ontario Water Resources Commission, has retired after 48 years of service with the provincial government. Most recently he has been active in helping to plan the commission's new laboratory and research center at Toronto.

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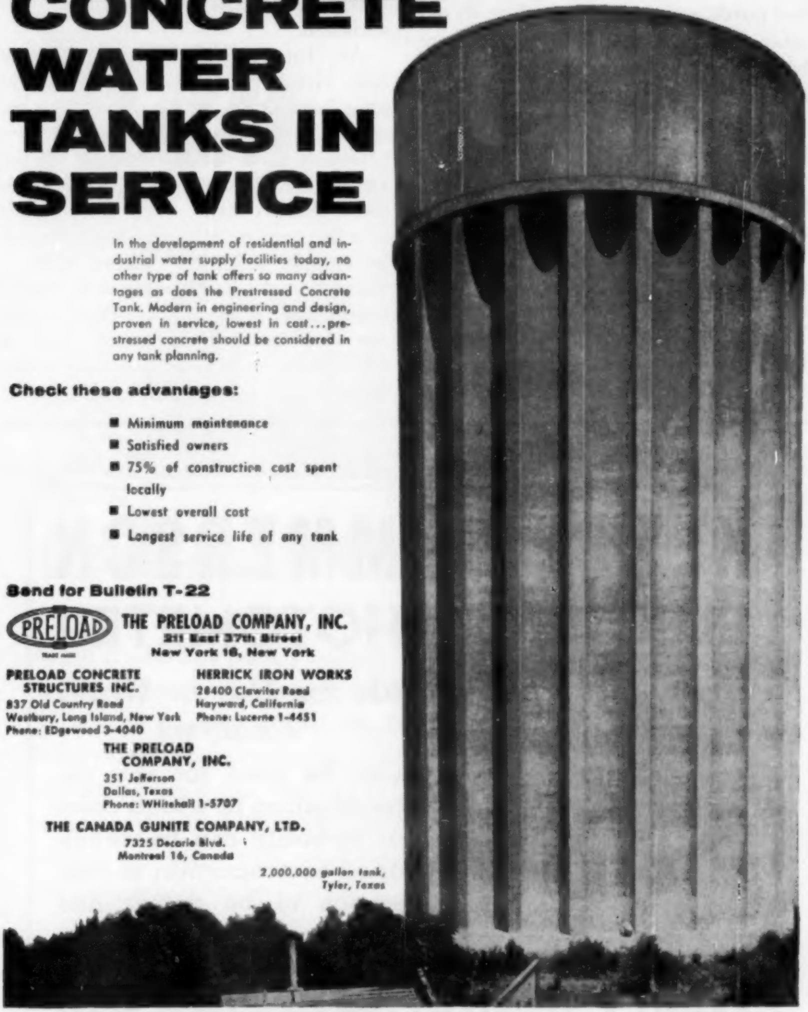

2,000,000 gallon tank, Tyler, Texas

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W. Victor Weir, President of St. Louis County Water Co. and former President of AWWA, was shot to death in his office on Nov. 19. His assailant was a restaurant operator who had purchased the water company's old office building and faced foreclosure because he was behind in his payments. During an interview at which Frank E. Dolson, vice-president of the company, was present, the assailant suddenly rose to his feet, drew a revolver from his belt, and shot Weir five times at point-blank range; he then turned the pistol on himself and put the sixth bullet through his own chest. Weir died at the hospital half an hour later. The assailant, who was not seriously hurt, has been indicted on a homicide charge.

Memorial services for Weir at his alma mater, Washington University in St. Louis, were attended by approximately 1,000 friends and associates on Nov. 21. Former AWWA Secretary Harry E. Jordan represented the Association.

An Honorary Member, as well as a Life Member, of AWWA, Weir had long been active in its affairs, having served as director, vice-president, and president. He was a recipient of the Diven Medal, the Goodell Prize, and the Fuller Award. One of the most effective personalities in the public water supply field, his talents both as engineer and administrator were widely recognized. His untimely death at the age of 57 comes as a painful shock to all who knew him or his accomplishments.

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Wallace T. Miller, research engineer for Cast Iron Pipe Research Association, has been appointed its assistant managing director. As aid to Managing Director Thomas F. Wolfe, Miller has been active in supervising CIPRA's campaign for public support of water facilities improvement. Formerly with New York Water Service Corp. and the Ossining, N.Y., water department, Miller came to CIPRA in 1954. Prior to that he had served as chairman of the New York Section of AWWA, as well as director. He is a recipient of the Fuller Award.

Pittsburgh-Des Moines Steel Co. and Hammond Iron Works, of Warren, Pa., have announced a merger. The combined company, operating under the Pittsburgh name, will specialize in metal fabrication and construction and will continue to manufacture Hammond products. Pittsburgh-Des Moines will now have twelve plants.

Coagulation—that is, the act of uniting into a coherent mass—is a procedure we have long wanted to see applied to the world as a whole. Thus, we are happy to report that AWWA has taken a first small step in that direction with the appointment of W. G. Woxholt, chief chemist of the Rand, South Africa, Water Board, to its Advisory Committee on Research on Water Coagulation. Mr. Woxholt, who has a staff of twelve chemists in his lab and responsibility for filtration plants serving a territory of 4,250 sq mi, has for some years been experimenting with the newer concepts of coagulation (see the July 1959 JOURNAL, p. 885). His appointment makes him, as far as we have been able to determine, the first non-North American to serve on an AWWA committee. Comes the coagulum, we hope!

Willard F. Rockwell, chairman of the board of Rockwell Mfg. Co., has received a Freedoms Foundation "Honor Certificate Award" for his speeches and writings in the field of economic education.

William D. Holmes, assistant manager and treasurer of Kankakee (Ill.) Water Co. since 1956, has been named vice-president and general manager of the firm. He succeeds Lynn O. Minor.

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Professional Services

Professional Services

Professional Services

Professional Services

Professional Services

Condensation

Index of Abstracts

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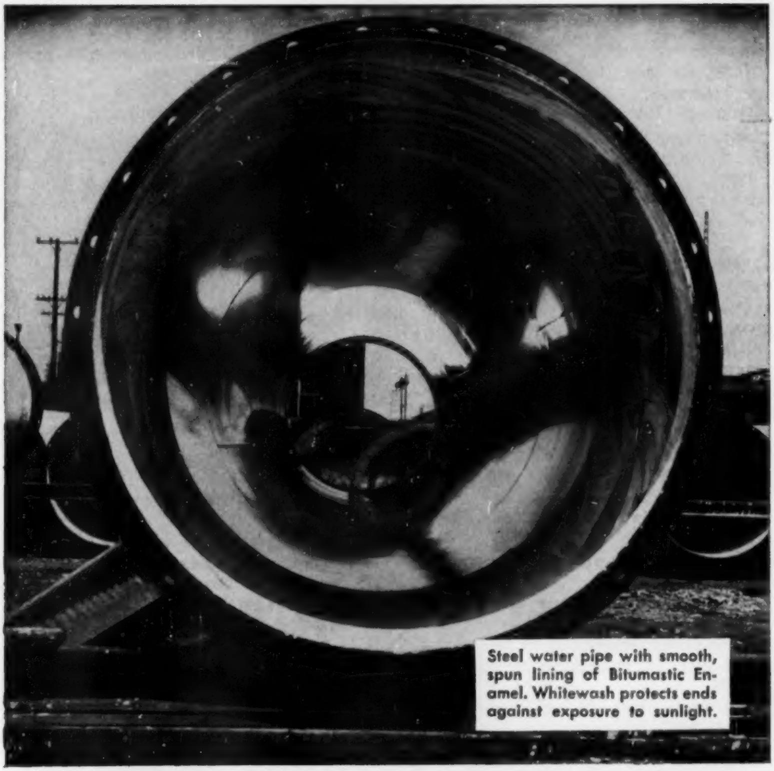

Steel water pipe with smooth, spun lining of Bitumastic Enamel. Whitewash protects ends against exposure to sunlight.

FLOW COEFFICIENT=155

The ebony-like finish on the inside surface of the steel water pipe shown above is a typical spun lining of Bitumastic 70-B AWWA Enamel. This type of lining has been tested and proved to have the highest flow coefficient available today.

That's one reason why steel pipe, lined with Bitumastic 70-B AWWA Enamel is such a good investment for water lines. Delivery stays high, too, year after year, since this enamel provides the best protection against tuberculation and incrustation known today.

Investigate steel water pipe—lined and coated with Bitumastic 70-B AWWA Enamel—for your next water-supply project.

Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pa.

KOPPERS ®

ONLY KOPPERS MAKES

BITUMASTIC

REG. U. S. PAT. OFF.

70-B ENAMEL

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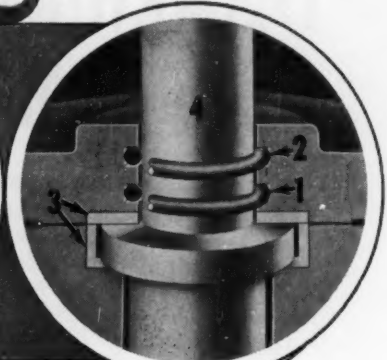
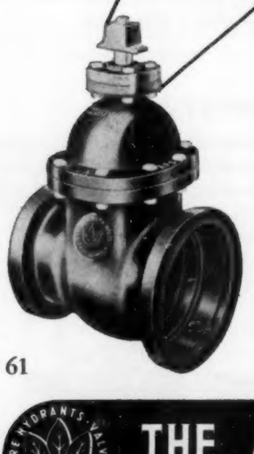
DOUBLE SEALING



SMITH VALVES WITH "O" RING SEALS



"O" Rings, due to their simplicity and reliability have been used for many years in military and industrial products. Smith non-rising stem valves are available with *double* "O" Ring seals. The lower "O" Ring (1) seals the internal pressure, while the upper "O" Ring (2) is a combined external dirt and reserve pressure seal. This construction eliminates packing, gland adjustment, and conventional stuffing box. All Smith AWWA specification valves are equipped with stem (thrust) collar bushings (3) and extra large, high strength bronze stems (4). These and other well known Smith superior design features assure positive operation, long service life, and minimum maintenance.

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FIRE HYDRANTS · VALVES · SINCE 1896

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

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Authors of Abstracted Articles

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only ONE PUSH makes it
PERMANENT...
AMERICAN
Fastite ★★ JOINT*
CAST IRON PIPE
Insert the single joint component—an exclusive dual-density, **double sealing** ★★ rubber gasket . . . lubricate the spigot . . . push pipe together . . . and you have a **permanent** bottle-tight joint.
That's American Fastite® Joint Cast Iron Pipe—American's new favorite for fast, simple installation and long service life.
American Fastite® Joint, an all-weather-laying joint, offers many special advantages for water, sewage and other liquid service.
Get the facts about American Fastite® and **compare** before you buy. Call your nearby American Cast Iron Pipe Company representative now.
*Patent applied for; Underwriters' Laboratories, Inc., approved.
AMERICAN
CAST IRON PIPE CO.
BIRMINGHAM ALABAMA
SALES OFFICES
New York City • Dallas
Chicago • Kansas City
San Francisco • Denver
Pittsburgh • Orlando
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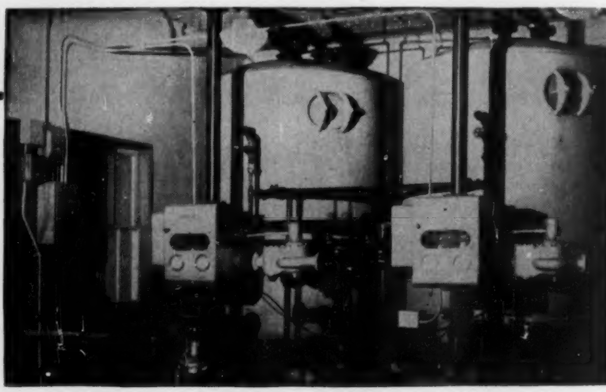

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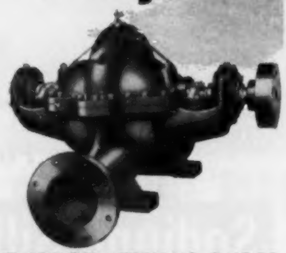
today there stands a city—

Where once, because there was no water, this farm failed. Helping supply water to municipalities everywhere are Peerless Type A centrifugal pumps. These horizontal work horses of the general purpose pumping field combine all the features necessary to outstanding, dependable pump performance. Split case design provides easy maintenance and inspection without disturbing piping. Superior hydraulic characteristics provide a capacity range of up to 70,000 gpm and a head range to 300 ft. A Type A's overall design efficiency and quality construction endow it first with a measurably longer service life and second with job versatility that qualifies it for nearly every pumping requirement your system may call for.

Get the finest—get the Peerless Type A horizontal centrifugal pump.



WRITE FOR BULLETIN NO. B-1300

PEERLESS PUMPS

Putting Ideas to Work

fmc

FOOD MACHINERY AND CHEMICAL CORPORATION

Peerless Pump Division

Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

Offices: New York; Cleveland; Chicago; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno. Distributors in Principal Cities. Consult your telephone directory.

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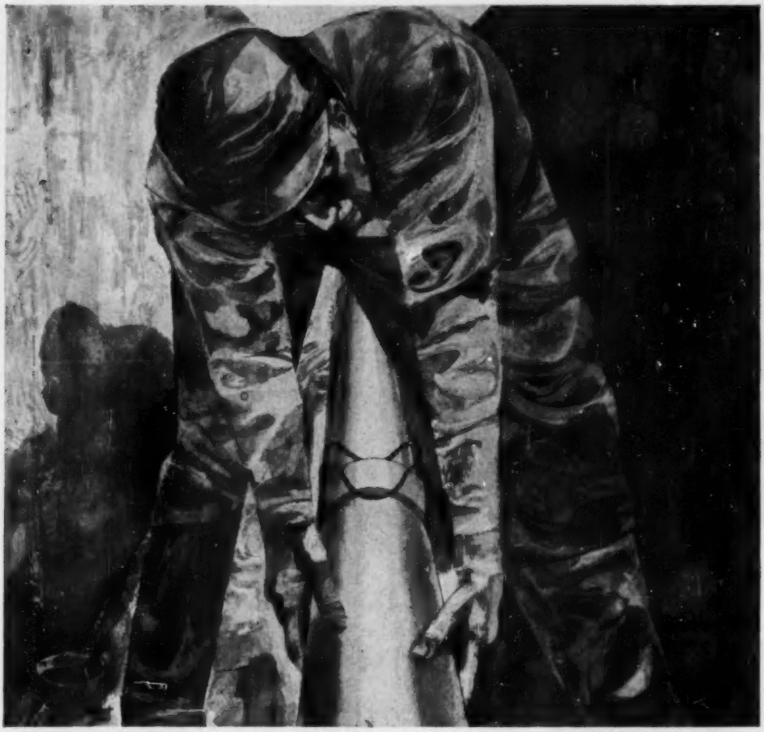

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CONTINUOUS PIPELINE CHEMICAL MIXING

THE HOMOMIX—provides instant, violent, uniform, and complete mixing of one or more chemicals or gases with water—continuously or intermittently, *without the use of a mixing tank!* Designed with one or more stages of direct-connected motor driven diffuser impellers rotating in blending chambers, it forms part of the influent piping. Discharges directly across the flow-through stream. Mixes instantaneously at the point of entry. Lift impeller can be added to provide additional head, if required. *Send for Technical Supplement HM and Bulletin 300.*

IRON AND CARBON DIOXIDE REMOVAL

THE FERROFILTER—removes iron, manganese, carbon dioxide, and other dissolved gases and odors—efficiently and economically, in one simple operation. Utilizes fine media in open aeration. *Write for Bulletin No. 252B.*

SOFTENING AND TURBIDITY REMOVAL

THE FLOCSETTLER—combines in one unit all modern concepts of water and waste treatment, including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. *Send for Technical Supplement FL.*

RAPID MIX AND FLOCCULATION UNITS

PADDLE-PROPELLER-RM TYPE MIXERS—for rapid mixing to obtain continuous blending of chemical with raw water.

PADDLE-DOWNFLO-FLOCCULATION UNITS—designed to efficiently carry out the slow mixing and flocculation functions required in the coagulation process. Choice of vertical and horizontal units. *Send for Technical Supplement PF.*

SLUDGE REMOVAL

POSITIVE FLIGHT CONVEYORS—for rectangular settling tanks. Heavy-duty solid shafting, babbitted plate sprockets. Heavy adjustable self-aligning wall bearings, furnished with foundation bolts welded to templates and eccentric washers for economical installation.

CIRCULAR CLARIFIERS—Structural steel bridge, steel flights in staggered position mounted on two radial trussed arms driven by motorized gear reduction unit. *Write for Bulletin 253B.*

PUMPS

Complete line of double-suction split-case single-stage, two-stage, end suction, axial flow, sludge, and deep well turbine pumps—for wide range of raw water, low lift, high lift, backwash, and general service pumping requirements. *Send for Bulletins 248A, 246A, 251A, 245A.*

Utilize our experience in engineering design and manufacture of field-proved equipment and pumps for water and waste treatment.

AMERICAN WELL WORKS

IN OUR 91ST YEAR
112 North Broadway
AURORA, ILLINOIS

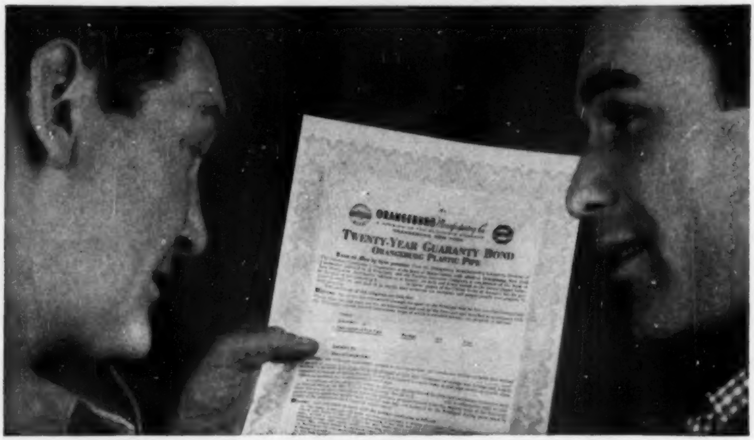
Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

Offices: Chicago • New York • Cleveland • Cincinnati • Kansas City • Sales Representatives throughout the World

(Continued from page 88 P&R)

(Continued on page 94 P&R)

Now you can tell customers "...the plastic pipe on <u>this</u> job is guaranteed and bonded for 20 years!"



It's ORANGEBURG® *SP*® *Plastic Pipe*

What a selling point! Tell your customer you use *slit-proof* Orangeburg *SP*—the *only* plastic pipe Guaranteed and Bonded for 20 years for cold water service. Tell him, too, the Bond will be made out in *his* name as written evidence you have used the finest-quality plastic pipe available.

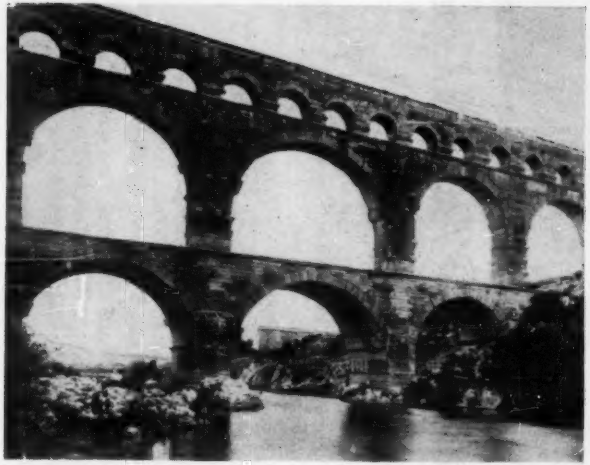
Under terms of Bond, repairs or replacements, INCLUDING LABOR COSTS, *due to failure of pipe will be made at Orangeburg's expense. You can't lose.*

And it's easy to apply for the Bond. When Orangeburg *SP* installation is completed, send "*Request for Bond*" Form to Orangeburg. After approval, Bond is sent direct to your customer.

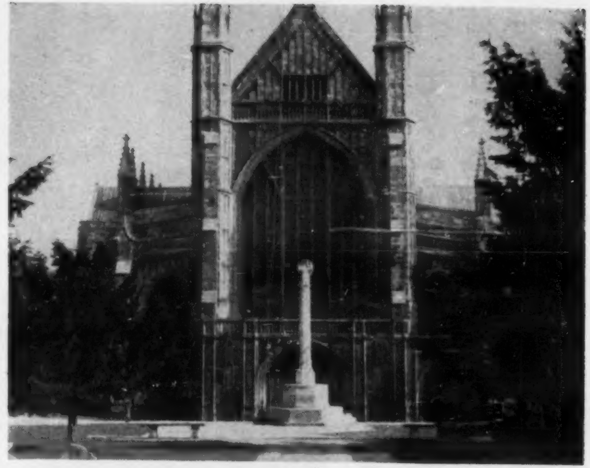
Be first to cash-in with Orangeburg *SP* Plastic Pipe and the exclusive iron-clad 20-year Guaranty Bond offer. See your Authorized Orangeburg Wholesaler or write Dept. JA-129.

Approved for drinking water by National Sanitation Foundation NSF LIFE

ORANGEBURG MANUFACTURING CO. • Orangeburg, N. Y. • Newark, Calif.
A Division of The Flintkote Company, Manufacturers of America's Broadest Line of Building Products



Aqueduct, 105 B. C.



Cathedral, 1065

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

INTERNATIONAL COOPERATION ADMINISTRATION needs General Water Geologist or Hydraulic Engineer competent in ground water geology to assist and advise officials of the Government of Sudan in developing a program of ground water resources and formulation of planning to govern drilling operations and to supervise ground water geology project and canal-lining project for irrigation system. Apply to Box G-2, Office of Public Health, International Cooperation Administration, Washington 25, D.C.

WATER UTILITY MANAGER

Exceptional opportunity for man with experience in water utility operation. College degree and administrative ability essential. Will be responsible for all operations in his district, reporting to Vice-President. Location Chicago area. Send complete resume of experience to Box 9121A, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

MANAGER—The Suffolk County Water Authority is seeking qualified personnel for district management positions. Salary range $7,200 to $8,500. Administrative ability together with some water works or other utility experience in office management and overall operation of a utility system is essential. Interview will be arranged on the basis of resume submitted. Write Suffolk County Water Authority, P.O. Box 37, Oakdale, New York.

Positions Wanted

REGISTERED PROFESSIONAL CHEMICAL ENGINEER. Nine years' technical experience working with municipal and industrial water treatment plants. Familiar with startup, operation, and control of all types of water-treating equipment. Chemical and bacteriological control. Family man, age 41. Presently employed as traveling service engineer. Desire responsible, supervisory position with municipality or industrial employment as water treatment or corrosion engineer with light travel only.

John R. Van Arsdale
14613 Karyl Drive, Hopkins, Minnesota

(*Continued from page 90 P&R*)


Layne

(Continued from page 52 P&R)

'Penny-Wise Water,' Lew Finch's favorite subject on the AWWA presidential trek last year, has finally been heard from again—this time, however, a little further along in its cycle, and in the words of one Ian Farquhar, assistant surveyor in Coventry, England:

Haul up the plug; pull on the chain!
And see the water down the drain.
Gurgling, guggling, down it goes,
Comes out someplace, where Lord knows.
Through tanks detritus, beds bacterial,
Filters circular of strange material.
Till in purest streams it flows,
Joining the river, from where it goes,
Through valleys lush and meadows pied,
Watering farm and countryside,
From whose dappled brow there blows
Zephyrs scented with the rose.
All this, dear friends, I wish to state
Obtained for the product of a penny rate.

Inasmuch as the English cycle is pretty much the same as our own, the left side of the road to the contrary notwithstanding,

Ian is probably saying to Lew:
Back is the water, back to you,
First to assure of both safety and taste,
Then to deliver en route to its waste,
For a penny's too little to make water's
worth
At all apparent except in its dearth!

Bartlett G. Bretz has been appointed southern sales manager of US Pipe & Foundry Co., succeeding Thomas W. McCreery, who retired after 47 years with the company. Bretz has been assistant western sales manager for US Pipe since 1957.

(Continued on page 98 P&R)

Tough, **fabricated steel pipe was the logical choice for the new water pumping station just completed in Washington, D. C.**

Buried in the bed of the Potomac River, steel pipe ranging in diameter from 24″ to 10 feet with coal tar enamel lining was used in conjunction with a complicated system of fittings, settling basins and filters. Steel pipe made the installation job easy and most economical . . . with assured long life.

Steel pipe is *universally* specified for the toughest assignments because of its Superior Strength, Bottle-Tight Joints, Ductility and Durability.

"Wherever Water Flows—STEEL PIPES IT BEST"

STEEL PLATE FABRICATORS FOUNDED 1933 ASSOCIATION

STEEL PLATE FABRICATORS ASSOCIATION

105 West Madison Street
Chicago 2, Illinois

(Continued from page 96 P&R)

J. J. Closner, vice-president in charge of sales and operations for Preload Co., New York, has been appointed president of the company, which builds prestressed concrete tanks and other structures. Closner has been with Preload since 1949.

Pfaudler Permutit, as part of the expansion of the Chemical Specialties Dept. of its Permutit Div., has added three regional sales managers: Timothy J. Hennigan, New England; David C. Loveland, central New Jersey; and Paul E. Browne, Greater Philadelphia.

Hazen & Sawyer, engineers, have moved into their new quarters at 360 Lexington Ave., New York. The firm also announces that its Detroit branch has discontinued operations.

John W. Cunningham, consulting engineer of Portland, Ore., died Sep. 17, 1959, at the age of 72. Born in Watertown, S.D., in 1887, he received his B.S. in civil engineering from the University of Wisconsin in 1908. After working on engineering projects in Spokane, Wash., he went to Portland in 1912, where, in 1914, he formed the consulting firm of Baar and Cunningham. This partnership was dissolved in 1937 and replaced by the present firm of John W. Cunningham & Associates.

Having joined AWWA in 1929, he was a Life Member. In 1953 he received the Fuller Award on nomination by the Pacific Northwest Section. He had also served as director and vice-president of ASCE, and as vice-president of FSIWA.

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Activated Carbon:
Industrial Chemical Sales Div.
Permutit Co.

Activated Silica Generators:
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Wallace & Tiernan Inc.

Aerators (Air Diffusers):
American Well Works
Carborundum Co.
General Filter Co.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Worthington Corp.

Alum (Sulfate of Alumina):
American Cyanamid Co., Process Chemicals Dept.
General Chemical Div., Allied Chemical Corp.

Ammonia, Anhydrous:
General Chemical Div., Allied Chemical Corp.
Jones Chemicals, Inc.

Ammoniators:
B-I-F Industries, Inc.—Proportioneers
Wallace & Tiernan Co., Inc.

Ammonium Silicofluoride:
American Agricultural Chemical Co.

Associations, Trade:
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Cast Iron Pipe Research Assn.
Steel Plate Fabricators Assn.

Brass Goods:
American Brass Co.
Hays Mfg. Co.
Mueller Co.

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International Salt Co., Inc.

Calcium Hypochlorite:
Jones Chemicals, Inc.
Olin Mathieson Chemical Corp.

Carbon Dioxide Generators:
Walker Process Equipment, Inc.

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Electro Rust-Proofing Corp.

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Centriline Corp.
Halliburton Oil Well Cementing Co.
Southern Pipe Div. of U.S. Industries

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B-I-F Industries, Inc.—Proportioneers
Graver Water Conditioning Co.
F. B. Leopold Co.
Permutit Co.
Precision Chemical Pump Corp.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

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(See Professional Services)

Chlorination Equipment:
B-I-F Industries, Inc.—Builders
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Wallace & Tiernan Inc.

Chlorine Comparators:
Klett Mfg. Co.
Wallace & Tiernan Inc.

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Dresser Mfg. Div.
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National Aluminate Corp.

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Worthington Corp.

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National Aluminate Corp.
Philadelphia Quartz Co.
Southern Pipe Div. of U.S. Industries

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DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Southern Pipe Div. of U.S. Industries
E. H. Wachs Co.

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E. H. Wachs Co.

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Calgon Co.
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Filter Materials:
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Permutit Co.
Stuart Corp.

Filters, incl. Feedwater:
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Dorr-Oliver Inc.
Graver Water Conditioning Co.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
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Cochrane Corp.
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Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
American Cast Iron Pipe Co.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Morgan Steel Products, Inc.
Southern Pipe Div. of U.S. Industries
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

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General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

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Tennessee Corp.

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B-I-F Industries, Inc.—Proportioneers
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Sparling Meter Co.
Wallace & Tiernan Inc.

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Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

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Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

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Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

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DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric Analysis Equipment:
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Wallace & Tiernan Inc.

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Mueller Co.
Southern Pipe Div. of U.S. Industries

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Kennedy Valve Mfg. Co.
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A. P. Smith Mfg. Co.
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Permutit Co.
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Leadite Co., Inc.

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Aqua Survey & Instrument Co.
Jos. G. Pollard Co., Inc.

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General Filter Co.
Infilco Inc.
Permutit Co.
Wallace & Tiernan Inc.

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W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

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W. S. Darley & Co.

Meter Boxes:
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Badger Meter Mfg. Co.
Dresser Mfg. Div.
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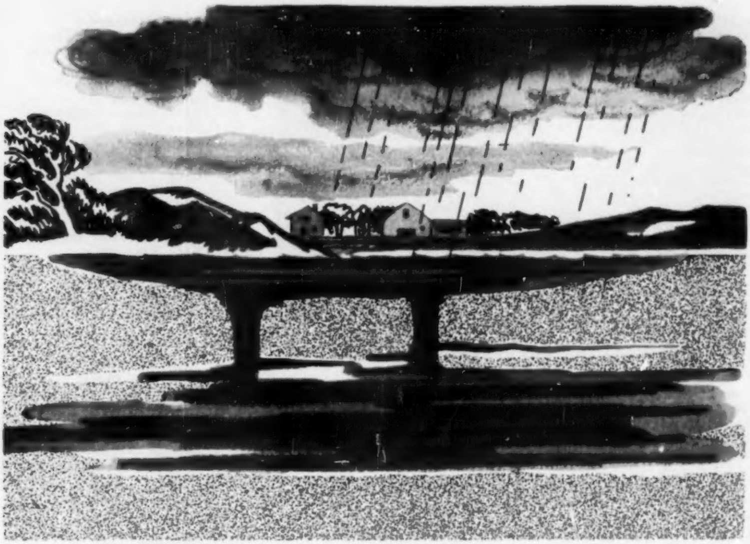
Gamon Meter Div., Worthington Corp.



UP-SIDE-DOWN WATER WELLS

There is comfort in the knowledge that today's engineers and water works men are craftsmen thoroughly familiar with the water problem and its remedy.

Extensive experiments are being made to control drought by producing artificial rainfall. "Upside-down wells" are used in some areas with declining water tables, run-off surface water during peak rainfall being injected into the ground through wells. Waste of water through evaporation in some dry areas is as much as eight feet of water per year from reservoir surfaces. Recent experiments in spreading a thin coat of cetyl alcohol on a water reservoir surface reduced evaporation as much as 65%. Considerable progress is being made in research and experiments designed to remove salt from sea-water.

It is no longer true that "much water goeth by the mill which the miller knoweth not of." Water works men know the facts of life so far as water is concerned, but they need public support.

This series is an attempt to put into words some appreciation of the water works men of the United States.

M&H VALVE
AND FITTINGS COMPANY
ANNISTON ALABAMA

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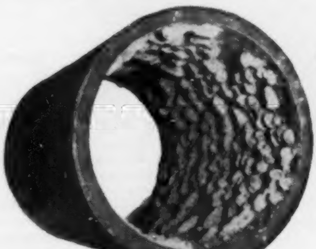
CALGON®

CONTROLS



TUBERCULATION

Tuberculation cuts down flow capacities . . . raises pumping power requirements . . . steps up costs. Calgon provides the simple, economical way to control this costly corrosion.

Calgon treatment is particularly effective after mechanical main cleaning because of its fast film-forming ability. Protection for freshly scoured metal surfaces is quickly built up and easily maintained. Calgon treatment is inexpensive—a few ppm control tuberculation and other corrosion problems as well.

A letter or phone call will bring you more information on the many ways in which Calgon can help. Or, an experienced Calgon engineer will be glad to make detailed recommendations on your specific problem.

CALGON COMPANY
DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.
Stops, Curb and Corporation:
Ford Meter Box Co.
Hays Mfg. Co.
Mueller Co.
Storage Tanks: see Tanks
Strainers, Suction:
James B. Clow & Sons
R. D. Wood Co.
Surface Wash Equipment:
Golden-Anderson Valve Specialty Co.
Permutit Co.
Swimming Pool Sterilization:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Wallace & Tiernan Inc.
Tank Painting and Repair:
Koppers Co., Inc.
National Tank Maintenance Corp.
Taylor Iron Works
Wilbur & Williams Co., Inc.
Tanks, Prestressed Concrete:
Preload Co., Inc.
Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.
Taylor Iron Works
Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.
Taste and Odor Removal:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Proportioneers
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Wallace & Tiernan Inc.
Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.
Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Turbines, Water:
DeLaval Steam Turbine Co.
Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.
Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
R. D. Wood Co.
Valves, Detector Check:
Hersey Mfg. Co.
Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Venturi Tubes:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.
Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.
Wilbur & Williams Co., Inc.
Water Softening Plants; see Softeners
Water Supply Contractors:
Layne & Bowler, Inc.
Water Testing Apparatus:
LaMotte Chem. Products Co.
Wallace & Tiernan Inc.
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Well Drilling Contractors:
Layne & Bowler, Inc.
Well Reconditioning and Formation Testing:
Halliburton Oil Well Cementing Co.
Layne & Bowler, Inc.
Wrenches, Ratchet:
Dresser Mfg. Div.
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1959 AWWA Directory.